

University of Toronto

LASER

SAFETY

PROGRAM

PROGRAM OUTLINE

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1.0 INTRODUCTION AND SCOPE

Under its Health and Safety Policy and the general provisions of the Occupational Health and Safety Act of Ontario, the University of Toronto is committed to taking every reasonable precaution for the health and safety of its employees and students.

The Laser Safety Program is intended to assist the University community in the effective control of laser hazards.

The basic elements of the control program are:

- 1) registration of all Class 3b and Class 4 lasers and laser systems;
- 2) requirement for inspections of Class 3b and Class 4 lasers and laser systems;
- 3) requirement for training and education of laser workers;
- 4) requirement for reporting accidents/incidents involving all Class 3b and Class 4 lasers and laser systems;
- 5) provision of medical surveillance;
- 6) requirement for personal protective equipment;
- 7) requirement for engineering controls;
- 8) requirement for administrative and procedural controls;
- 9) requirement for auditing the implementation and effectiveness of the program.

Objective of the Laser Safety Program

It is the objective of this laser safety program to effectively control laser hazards in accordance with the University Health and Safety Policy and the general provisions of the Occupational Health and Safety Act of Ontario.

Scope

This program applies to all Class 3b and Class 4 lasers and laser systems in controlled areas (indoors) and to all those identified as principal investigators, laser supervisors and laser workers (see definitions).

2.0 DEFINITIONS

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 System

Assembly of electrical, mechanical, and optical components which includes one or more lasers.

Lasers/Laser Systems --- Class 3b

These are moderate power lasers (continuous wave: 5 - 500 mW, pulsed: 10 J/cm² - or the diffuse reflection limit, whichever is lower). In general, Class 3b lasers will not be a fire 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 American National Standard for Safe Use of Lasers (ANSI Z136.1-1993).

Lasers/Laser Systems --- Class 4

These are high power lasers (continuous wave: >500 mW). In general, Class 4 lasers are hazardous to view under any condition (directly or diffusely scattered) and are a potential fire hazard and a skin hazard. For further details, consult the American National Standard for Safe Use of Lasers (ANSI Z136.1-1993).

Principal Investigator

An individual who has charge of a laser laboratory and/or principal authority for Class 3b or Class 4 lasers and laser systems.

Laser Supervisor

An individual who has been delegated supervisory responsibilities by a principal investigator for Class 3b and Class 4 lasers and laser systems and laser workers.

Laser Worker

An individual who operates or works in proximity to Class 3b or Class 4 lasers and laser systems.

Laser Safety Officer

One who is directed by the Office of Environmental Health and Safety/Laser Safety Committee and is knowledgeable in the evaluation and control of laser hazards.

Maximum Permissible Exposure (MPE)

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

Nominal Hazard Zone (NHZ)

The nominal hazard zone describes the 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.

3.0 RESPONSIBILITIES

This section outlines the responsibilities for the implementation of the laser safety program within the University.

3.1 Laser Safety Committee

The membership is appointed by the Vice-President, Administration and Human Resources and consists of at least (4) principal investigators and (2) laser supervisors with expertise in laser technology and/or assessment of laser hazards, the Director of Environmental Health and Safety and the Manager, Occupational Hygiene and Safety.

The committee has the following responsibilities:

1. To establish and maintain standards and guidelines for the safe use of lasers within the University;
2. To provide expert advice on laser safety hazards;
3. To approve appropriate laser safety training program materials;
4. To review and act on the recommendation of the Laser Safety Officer to suspend, restrict or terminate the operation of a Class 3b or Class 4 laser and laser system;
5. To review and update the laser safety program on a regular basis;
6. To report annually to the Vice-President, Administration and Human Resources on the operation of the Laser Safety Program.

3.2 Department Head

The Department Head has the following responsibilities within this program:

1. To identify all principal investigators under his/her authority and ensure that they clearly understand their duties and responsibilities as individuals with principal authority for Class 3b and Class 4 lasers and laser systems;
2. To ensure that all components of the Control Program are implemented in the department.

3.3 Laser Safety Officer

The laser safety officer (LSO) is one who is directed by the Office of Environmental Health and Safety/Laser Safety Committee and is knowledgeable in the evaluation and control of laser hazards. The LSO has the following responsibilities in his/her jurisdiction:

1. To provide consultative services on evaluation and control of laser hazards;
2. To inspect all new Class 3b and Class 4 lasers and lasers systems;
3. To classify all "home-built" and/or modified, Class 3b and Class 4 lasers and laser systems;
4.
 - a) To recommend the suspension, restriction, or termination of the operation of a Class 3b or Class 4 laser or laser system which does not meet acceptable safety standards;
 - b) To document the technical reasons for the decision in 4(a) above and report it to the Department Head and the Laser Safety Committee;
5. To inspect (at least annually) all Class 3b and Class 4 laser facilities for compliance with the University's Laser Safety Program and report to the Office of Environmental Health and Safety and the Laser Safety Committee.

3.4 Principal Investigator

An individual who has charge of a laser laboratory and/or principal authority for Class 3b or Class 4 lasers and laser systems. The principal investigator may **delegate** some or all of his/her responsibilities to a laser supervisor. Note however, the principal investigator cannot **discharge** these responsibilities to a laser supervisor. The principal investigator has the following responsibilities:

1. To register all Class 3b and Class 4 lasers and laser systems and deregister decommissioned ones with the Office of Environmental Health and Safety;
2. To identify all Class 3b and Class 4 laser workers under his/her authority to the Office of Environmental Health and Safety;
3. To identify all Class 3b and Class 4 laser supervisors under his/her authority to the Office of Environmental Health and Safety;
4. To ensure that laser supervisors participate in the University's Laser Safety Program training prior to operating or working in proximity to Class 3b or Class 4 lasers and laser systems;
5. To ensure that laser workers participate in the University's Laser Safety Program training prior to operating or working in proximity to Class 3b or Class 4 lasers and laser systems; if this is not possible --- to provide (either personally or through a laser supervisor) instruction and supervision until such training is available;
6. To provide and enforce the use of the appropriate personal protective equipment when required;
7. To provide written standard operating procedures (SOPs) for all Class 3b

(optional) and Class 4 lasers and laser systems and to ensure that each laser is used only under conditions and in locations which meet the requirements of the SOP(s);

8. To ensure that each laser supervisor/worker is trained in the safe operation of the specific Class 3b and/or Class 4 lasers and laser systems that he/she will operate;
9. To ensure that all Class 3b and Class 4 lasers and laser systems are stored securely and safely when not in use so that they are not usable by unauthorized personnel or under unauthorized conditions;
10. To permit only trained laser supervisors/workers to operate or work in proximity to Class 3b or Class 4 lasers or lasers systems.
11. To ensure that all administrative and engineering controls are followed.
12. To correct unsafe conditions in a timely manner.
13. To ensure that all laser workers and laser supervisors participate in the University's medical surveillance program;
14. To ensure that all spectators are properly informed of and protected from potential laser hazards;
15. To cancel laser supervisor/worker privileges until satisfied that he/she fully meets the requirements of this control program;
16. To report known or suspected accidents to the Laser Safety Officer/Office of Environmental Health & Safety within 24 hrs.of the accident;

3.5 Laser Supervisor

An individual who has been delegated supervisory responsibilities for Class 3b and Class 4 lasers and laser systems and laser workers. He/she has the following responsibilities:

1. To participate in the University's Laser Safety Program training prior to operating or working in proximity to Class 3b or Class 4 lasers and laser systems;
2. To be familiar with all operational procedures and specific safety hazards of the Class 3b or Class 4 lasers and laser systems that he/she will operate/oversee;
3. To operate Class 3b and Class 4 lasers and laser systems safely and in a manner consistent with safe laser practices, requirements and written SOPs;
4. To operate Class 3b and Class 4 lasers and laser systems only under the conditions authorized by the principal investigator;

5. To report all unsafe conditions to the principal investigator;
6. To report to the principal investigator any medical conditions that could cause him/her to be at increased risk for chronic exposure, eg. photosensitivity of the skin, use of photosensitizing medications, and dermatological abnormalities of the skin;
7. To participate in the University's medical surveillance program;
8. As directed by the principal investigator, to provide instruction and supervision to laser workers;
9. As directed by the principal investigator, to conduct other activities associated with the University's Laser Safety Program;
10. To promptly report known or suspected accidents and unsafe conditions to the principal investigator.

3.6 Laser Worker

The laser worker is one who operates or works in proximity to Class 3b or Class 4 lasers and laser systems. He/she has the following responsibilities:

1. To participate in the University's Laser Safety Program training prior to operating or working in proximity to Class 3b or Class 4 lasers and laser systems; if this is not possible - to accept appropriate instruction and supervision from the principal investigator or laser supervisor until such training is available;
2. To be familiar with all operational procedures and specific safety hazards of the Class 3b or Class 4 lasers and laser systems that he/she will operate;
3. To operate Class 3b and Class 4 lasers and laser systems safely and in a manner consistent with safe laser practices, requirements and written SOPs;
4. To operate Class 3b and Class 4 lasers and laser systems only under the conditions authorized by the laser supervisor/principal investigator;
5. To report all unsafe conditions to the laser supervisor/principal investigator;
6. To report to the laser supervisor/principal investigator any medical conditions that could cause him/her to be at increased risk for chronic exposure, eg. photosensitivity of the skin, use of photosensitizing medications, and dermatological abnormalities of the skin;
7. To participate in the University's medical surveillance program;
8. To promptly report known or suspected accidents and unsafe conditions to the laser supervisor/principal investigator.

3.7 Office of Environmental Health & Safety

The Office of Environmental Health & Safety has the following responsibilities within the Laser Safety Program:

1. To provide a Laser Safety Officer to fulfill the requirements of the Laser Safety Program;
2. To prepare and maintain a university-wide registry of all Class 3b and Class 4 lasers and laser systems and to deregister decommissioned ones;
3. To co-ordinate worker training and maintain such records;
4. To maintain a medical surveillance program;
5. To notify principal investigators of the laser safety program training and medical surveillance of all laser supervisors/workers under their authority;
6. To investigate all accidents/incidents involving Class 3b and Class 4 lasers and laser systems;
7. To provide administrative support to the Laser Safety Committee;
8. To audit the implementation and effectiveness of this program on an on-going basis.

4.0 REGISTRATION OF LASERS

There are two primary reasons for preparing and maintaining a record of all Class 3b and Class 4 lasers and laser systems. These are:

- 1) to identify areas where Class 3b and Class 4 lasers are present so that appropriate administrative and engineering controls may be put in place.
- 2) to enable the lasers and laser systems to be inspected on a regular basis for compliance with the University's Laser Safety Program.

4.1 The record shall contain the following information (see Appendix A):

- 1) type of laser (CO₂, Nd: YAG, He-Ne, etc).
- 2) production class (commercial, modified, "home-built")
- 3) laser classification (Class 3b or Class 4)
- 4) the location of the laser (building and room #)
- 5) the principal investigator (the person with principal authority for the laser)
- 6) the principal investigator's department
- 7) the proposed use (research, medical or therapeutic application, undergraduate teaching, etc)

4.2 The principal investigator is responsible for the registration of all Class 3b and Class 4 lasers and laser systems and the deregistration of decommissioned ones (see registration form in **Appendix A**).

4.3 The Office of Environmental Health & Safety is responsible for the preparation and maintenance of the laser registry.

5.0 LASER SAFETY INSPECTIONS

Periodic inspections of Class 3b and Class 4 lasers and laser systems are an integral part of the laser safety program; it provides some indication as to whether or not these lasers and laser systems are being operated in a safe manner.

- 5.1 The Laser Safety Officer is responsible for inspecting all new Class 3b and Class 4 lasers and laser systems and also (at least annually) all Class 3b and Class 4 lasers and laser facilities for compliance with the University's Laser Safety Program and report to the Office of Environmental Health and Safety and the Laser Safety Committee. The form that will be used in these inspections is attached as **Appendix B**.

6.0 TRAINING AND EDUCATION

- 6.1 All laser supervisors must participate in the University's Laser Safety Program training prior to operating or working in proximity to Class 3b or Class 4 lasers and laser systems;
- 6.2 All laser workers must participate in the University's Laser Safety Program training prior to operating or working in proximity to Class 3b or Class 4 lasers and laser systems; if this is not possible – to accept appropriate instruction and supervision from the principal investigator or laser supervisor until such training is available;
- 6.3 This training will include the following:
- \$ Legislation and the University Laser Safety Program
 - \$ Responsibilities
 - \$ Laser Basics
 - \$ Laser Hazards
 - \$ Bioeffects
 - \$ Laser Safety Standards
 - \$ Laser System Classification
 - \$ Control Measures
 - \$ Laser Eye Protection
 - \$ Medical Surveillance
 - \$ Non-Beam Hazards
 - \$ Laser Accident Reports
 - what can we learn from them
 - \$ Workshop
 - Calculations
 - Problems
 - Demonstrations
 - Group discussions
 - Quiz
- 6.4 All laser supervisors must also be familiar with all standard operating procedures and specific safety hazards of the Class 3b and Class 4 lasers and laser systems that he/she will operate/oversee.
- 6.5 All laser workers must also be familiar with all standard operating procedures and specific safety hazards of the Class 3b and Class 4 lasers and laser systems that he/she will operate.
- 6.6 The Office of Environmental Health and Safety is responsible for maintaining records of all laser supervisors and laser workers who have participated in the laser safety program training and for notifying principal investigators of this participation.

7.0 ACCIDENT/INCIDENT REPORTING AND EMERGENCY RESPONSE

- 7.1 University policy requires the reporting of all accidents/incidents which **result in** or have the **potential to result in** personal injury.

Reporting of accidents involving death, critical injury, lost time or health care is required for **employees** under the Occupational Health and Safety Act and the Workplace Safety and Insurance Act, while University policy requires the reporting of accidents/incidents involving **students and visitors and other persons on university premises**.

Therefore, **reportable accidents/incidents** are those which:

- \$ result in personal injury (including those requiring first aid); **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 university premises; **or**
- \$ occur to a university employee during the course of his/her work either on or off university premises.

- 7.2 The principal investigator is responsible for reporting all accidents/incidents involving Class 3b and Class 4 lasers and laser systems:

- for incidents involving employees, the principal investigator must complete, and sign, the University "*Accident/Incident/Occupational Disease Report*" ----- copies of which are available from the Office of Environmental Health and Safety. The completed form must be faxed or hand-delivered to the Office of Environmental Health and Safety.
- for incidents involving students, visitors and others, the principal investigator must complete the "*CURIE*" *Accident Form* ----- copies of which are available from the Department of Insurance and Risk Management. The completed form must be faxed or hand-delivered to the Department of Insurance and Risk Management with a copy to the Office of Environmental Health and Safety.

- 7.3 All reportable accidents/incidents must be reported to the Office of Environmental Health and Safety within 24 hrs. in order that the appropriate report be filed with the Workplace Safety and Insurance Board.

- The Workplace Safety and Insurance Board levies a fine of \$250 for late reporting of a **lost time or health care claim**. Where this late reporting is a result of the failure of a department to report the incident to Environmental Health and Safety within the required time, the fine will be charged to that department.

7.4 In addition to the reporting requirements outlined on the previous page, all ***Critical Injuries** to employees must be reported immediately to the Ministry of Labour. The principal investigator is therefore responsible for taking the following steps:

- \$ procure immediate medical attention (978-2222)
- \$ notify the University of Toronto Police
- \$ notify the Office of Environmental Health and Safety
- \$ notify the Ministry of Labour
- \$ notify the appropriate joint health and safety committee for the workplace
- \$ notify the appropriate union (if any) representing the injured employee
- \$ ensure that the site of the accident remains undisturbed until a Ministry of Labour inspector has arrived
- \$ investigate and prepare a written report on the circumstances of the accident.

***Critical Injury** is defined as an injury of a serious nature that:

- places life in jeopardy
- produces unconsciousness (or an altered state of consciousness)
- results in substantial loss of blood
- involves the fracture of a leg or arm, but not a finger or toe
- involves the amputation of a leg, arm, hand or foot, but not a finger or toe
- consists of burns to a major portion of the body, or
- causes the loss of sight in an eye.

7.5 When a known or suspected accident is reported to the principal investigator/laser supervisor or the Office of Environmental Health and Safety, the laser worker with a suspected injury will be referred to the appropriate University Health Service or hospital/physician/ophthalmologist.

8.0 MEDICAL SURVEILLANCE

All Class 3b and Class 4 laser supervisors and laser workers are required to participate in the University's laser medical surveillance program.

The purpose of the laser medical surveillance is twofold:

1. to establish a baseline of ocular conditions before exposure to laser radiation.
2. to detect early signs of any ocular damage and to initiate prompt treatment.

8.1 A preassignment medical assessment is required before a laser supervisor/worker begins work in an area involving Class 3b or Class 4 lasers and laser systems. This assessment will include:

- \$ medical history pertinent to conditions that can involve the eyes;
- \$ medical history and physical examination for individuals working with systems that operate in the ultraviolet region of the electromagnetic spectrum;
- \$ measures of visual function related to the different parts of the eye: cornea, iris, lens, vitreous humour, macula, retina, etc.;
- \$ visual acuity (corrected: bring glasses!);
- \$ colour vision;
- \$ Amsler Grid (to assess blind spots and distortions)
- \$ individuals with significant eye problems or who are functionally one-eyed will be referred to an ophthalmologist.

8.2 Individuals will be counselled regarding common medicines that are "photoactive".

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

8.4 When a known or suspected accident is reported to the principal investigator/laser supervisor or the Office of Environmental Health and Safety, the laser worker with a suspected injury will be referred to the appropriate University Health Service or hospital/physician/ophthalmologist.

8.5 All medical records will be kept in strict confidence. Status reports regarding fitness to work will be provided to the laser worker, the principal investigator/laser supervisor and on file in the Office of Environmental Health and Safety.

8.6 Principal investigators are responsible for ensuring that all Class 3b and Class 4 laser supervisors and laser workers under their authority participate in the medical surveillance program by submitting the names of these individuals to the Office of Environmental Health and Safety.

8.7 The Office of Environmental Health and Safety is responsible for maintaining records of all laser supervisors and laser workers who have participated in the medical surveillance program and for notifying principal investigators of this participation.

9.0 PERSONAL PROTECTIVE EQUIPMENT

Enclosure of the laser equipment or beam path is the preferred method of control, since enclosure will isolate or minimize the hazard; if this is not entirely feasible and other control measures do not adequately prevent access to direct or reflected beams at levels above the **Maximum Permissible Exposure (MPE)**, it may be necessary to use personal protective equipment.

- 9.1 The principal investigator shall ensure that laser protective eyewear is available and worn by all personnel within the Nominal Hazard Zone of Class 3b and Class 4 lasers and laser systems where the exposures above the **Maximum Permissible Exposure** can occur.

The principal investigator shall provide laser protective eyewear that is clearly labelled with the optical density and the wavelength for which protection is afforded.

Laser supervisors/workers shall wear protection as required and should inspect laser protective eyewear for damage prior to use, replacing eyewear, if faulty. Also, protective eyewear shall be cleaned periodically, according to the manufacturer's instructions.

- 9.2 For Class 3b or Class 4 lasers and laser systems operating in the **ultraviolet**, skin protection shall be utilized if chronic (repeated) exposures are anticipated at or near the applicable **Maximum Permissible Exposure** for skin.

If engineering controls are not entirely feasible, then skin covers and/or "sun screen" creams are recommended. Most gloves will provide some protection against this radiation. Tightly woven fabrics and opaque gloves provide the best protection. A laboratory coat can provide protection for the arms.

- 9.3 The use of other personal protective equipment (eg. respirators, hearing protection, fire extinguishers, and additional local exhaust ventilation) may be required whenever engineering controls cannot provide protection from a potentially harmful environment.

10.0 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 lasers and laser systems during operation and maintenance.

Commercial laser products will be certified by the manufacturer and will incorporate some engineering controls. Additional controls such as those outlined in this section shall be considered in order to reduce the potential for hazard associated with some applications of Class 3b and Class 4 lasers and laser systems.

In some research and development applications, **some of these engineering controls may be impractical** and it will be necessary to substitute administrative and procedural controls (see section 11.0) to provide equivalence in protection; for these applications, a hazard analysis shall be conducted and in order to assure safe operation, this must be done in conjunction with the Laser Safety Officer (LSO) who must approve these control measures.

Following are the control measures that are normally required for Class 3b and Class 4 lasers and laser systems:

10.1 Protective Housing

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

10.2 Laser Use without Protective Housing

In some applications of research and development, the operation of lasers 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. These controls may include, but are not 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

10.3 Interlocks on Protective Housing

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.

The protective housing interlock shall not be defeated or overridden during operation unless the provisions of "**Laser Use without Protective Housing**" (above) have been fully implemented.

10.4 **Service Access Panels**

These panels are part of the protective housing which are intended to be removed by service personnel only and permit direct access to laser radiation. They must either: 1) be interlocked (fail-safe interlock not required), or 2) require a tool for removal and shall have an appropriate warning label.

10.5 **Key Control**

All Class 4 lasers shall be provided with a master switch which is operated by a removable key or coded access (such as a computer code).

10.6 **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.

10.7 **Collecting Optics**

All optical instruments intended for viewing a laser or laser system must be equipped with suitable means (eg. filters, attenuators, or interlocks) to preclude the transmission of laser light in excess of the MPE under all conditions of operation and maintenance.

10.8 **Enclosed Beam Path**

In applications of Class 3b or Class 4 lasers or laser systems where the entire beam path is enclosed, and the enclosure fulfills all the requirements of a protective housing (ie. limits the laser radiation exposure at or below the applicable MPE), no further controls are required.

10.9 **Limited Open Beam Path**

There are some applications where the major part of the laser system is enclosed, allowing only a very small area of the beam to remain accessible. In such instances, a hazard analysis is required (in conjunction with the LSO) to establish the Nominal Hazard Zone (NHZ). The analysis will define the area where laser radiation is accessible at levels above the appropriate MPE and will define the zone requiring control measures. Controls must be established that are appropriate to the magnitude and extent of the accessible radiation. Frequently, the hazard analysis will define an extremely limited NHZ and **procedural controls** can provide adequate protection.

10.10 **Totally Open Beam Path**

In applications of Class 3b or Class 4 lasers or laser systems where the entire beam path is unenclosed, a laser hazard analysis is required (in conjunction with the LSO) to establish the NHZ. The analysis will define the area where laser radiation is accessible at levels above the appropriate MPE and will define the zone requiring control measures. A **laser controlled area** shall be established in this zone and appropriate control measures shall be implemented within the NHZ based on the classification associated with the maximum level of accessible laser radiation.

10.11 **Remote Interlock Connector**

The remote interlock connector (eg. "Panic Button") deactivates the laser or reduces the accessible radiation to levels at or below the applicable MPE.

10.12 **Beam Stop or Attenuator**

Each Class 4 laser or laser system must be provided with a permanently-attached beam stop or attenuator capable of preventing the emission of laser light in excess of the MPE when the beam is not required.

10.13 **Activation Warning Systems**

An activation warning system is required on all Class 4 lasers or laser systems. This could be an audible system eg. an alarm, or a warning light (visible through protective eyewear), or a verbal "countdown" command during activation or startup of the laser.

10.14 **Emission Delay**

This is 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.

10.15 **Equipment Labels**

All commercial Class 3b and Class 4 lasers are labelled. Home built Class 3b and Class 4 lasers shall have appropriate warning labels affixed to a conspicuous place on the laser housing or control panel.

10.16 **Area Posting**

An area which contains a Class 3b or Class 4 laser or laser system shall be posted with appropriate signage (see **Appendix C**). Also, a notice sign shall be posted outside a temporary laser controlled area.

10.17 **Indoor Laser Controlled Area**

When the beam path of a Class 3b or Class 4 laser or laser system is **totally open**, a laser controlled area must be established and adequate control measures must be implemented.

\$ Control measures normally required for both Class 3b and Class 4 lasers

- (1) Posting with appropriate warning signs. Sign must be posted at the entryway and, if necessary, within the laser controlled area. For details on signs, see **Appendix C**.
- (2) Operation by authorized personnel only.
- (3) Operation or attendance by appropriately trained personnel only.
- (4) Limitation of path beyond indoor controlled area.

\$ Control measures recommended for Class 3b but normally required for Class 4 lasers

- (1) Direct supervision of an individual knowledgeable in laser safety.
- (2) Access to the area by spectators is limited and requires approval.
- (3) Any potentially hazardous beam must be terminated in a beam stop of appropriate material.
- (4) Only diffusely reflecting materials must be used in or near the beam path, where feasible.
- (5) Personnel within the laser controlled area must be provided with the appropriate eye protection.
- (6) The laser must be secured such that the exposed beam path is located above or below the normal eye level of a person in any standing or seated position.
- (7) All windows, doorways, open portals, etc. from an indoor facility must be either covered or restricted to reduce the transmitted laser radiation to or below the applicable ocular MPE level.
- (8) Require storage or disabling (for example, removal of the key) of the laser or laser system when not in use to prevent unauthorized use.

\$ Control measures normally required for Class 4 lasers

- All personnel entering a Class 4 area must be appropriately trained, provided with appropriate protective equipment, and follow all applicable administrative and procedural controls.
- All Class 4 area/entryway safety controls must allow both rapid entrance and exit to the laser controlled area under any conditions.
- For emergency conditions there must be a clearly marked "Panic Button" (switch or equivalent device) to quickly deactivate the laser or reduce the output to safe levels.
- In addition the Class 4 laser controlled area must incorporate **one of the following options** for area or entryway safety controls:

(1) Non-Defeatable (non-override) Area or Entryway Safety Controls.

These may be safety latches, entryway or area interlocks (e.g., electrical switches, pressure sensitive floor mats, infrared detectors) used to deactivate the laser or reduce the output to safe levels when the door is open; **or**

(2) Defeatable Area or Entryway Safety Controls.

Defeatable safety latches, entryway or area interlocks may be used if non-defeatable controls limit the intended use of the laser when operation without interruption is necessary, for example, during long term testing. These safety controls may be overridden to allow access if it is clearly evident that there is no laser hazard at the point of entry. The authorized personnel requiring entry must be adequately trained and provided with adequate personal protective equipment: **or**

(3) Procedural Area or Entryway Safety Controls.

Where door interlocks are not feasible or are inappropriate, the following procedural controls apply:

- (a) All authorized personnel must be adequately trained and provided with adequate personal protective equipment upon entry.
- (b) A door, blocking barrier, screen, curtains, etc. must be used to block or attenuate the laser beam at the entryway to assure that laser radiation outside the area does not exceed MPE, nor anyone gets exposed above the MPE immediately upon entry.
- (c) In this case there shall be a warning light or sound at the entryway indicating that the laser is energized and operating.

A lighted warning sign or a flashing light are two examples how to appropriately accomplish this requirement. Alternatively, a light assembly may be interfaced to the laser in such a manner that: one light indicates when the laser is not operational (high voltage off), *and* a second light indicates when the laser is powered up (high voltage applied - but no laser emission), *and* a third light (flashing optional) indicates when the laser is operating (emission on).

10.18 Temporary Laser Controlled Area

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

The following table summarizes the engineering control measures that are normally required for Class 3b and Class 4 lasers and laser systems:

ENGINEERING CONTROL MEASURES	CLASSIFICATION	
	3b	4
Protective Housing	✓	✓
Without Protective Housing	LSO to determine	
Interlocks on Protective Housing	✓	✓
Service Access Panel	✓	✓
Key Control	○	✓
Viewing Portals (reduce light below MPE)	✓	✓
Collecting Optics (reduce light below MPE)	✓	✓
Enclosed Beam Path	NC	NC
Limited Open Beam Path	NHZ	NHZ
Totally Open Beam Path	NHZ	NHZ
Remote Interlock Connector	○	✓
Beam Stop or Attenuator	○	✓
Activation Warning Systems	○	✓
Emission Delay	X	✓
Labels	✓	✓
Area Posting	✓	✓
Indoor Laser Controlled Area	✓	✓
Temporary Laser Controlled Area	✓	✓

LEGEND

- ✓ --- Normally required
- --- Optional
- X --- No requirement
- NC --- No further controls required
- NHZ --- Nominal Hazard Zone analysis required

11.0 ADMINISTRATIVE AND PROCEDURAL CONTROLS

Engineering controls must be given primary consideration in instituting a control measure program for limiting access to laser radiation. If some of these engineering controls are impractical or inadequate, then administrative and procedural controls that provide equivalent protection shall be used.

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.

Following are the administrative and procedural controls that are normally required for Class 3b and Class 4 lasers and laser systems:

11.1 Standard Operating Procedures (SOPs)

Standard operating procedures (SOPs) for Class 4 lasers and laser systems shall be maintained with the laser equipment and must always be available as a reference for all laser workers; SOPs may include the laser instruction manual (prepared by the manufacturer) and as appropriate, additional written information to ensure compliance with good work practices and safety.

SOPs are required for the following Class 4 lasers and laser systems:

- Experimental Set-up and System Alignment;
- Routine Operation;
- Laser Maintenance and Set-up; and
- Non-standard/modified lasers and laser systems.

11.2 Output Emission Limitations

If excessive power or radiant energy is accessible during operation or maintenance of a Class 3b or Class 4 laser or laser system, the laser worker must take action as required to reduce the levels of accessible power or radiant energy to that which is commensurate with the required application.

11.3 Laser Worker Training

Education and Training shall be provided for all laser workers (see section 6 of this program). The level of training shall be commensurate with the level of potential hazard.

11.4 Authorized Personnel

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

11.5 Alignment Procedures

Laser incident reports have repeatedly shown that an ocular hazard may exist during beam 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 SOPs outlining alignment methods shall be available.

11.6 Protective Equipment

Eye protection (goggles or spectacles) or skin protection (clothing and gloves) and other devices which have been specifically selected for suitable protection against laser radiation may be required when other control measures are inadequate to eliminate potential exposure in excess of the applicable MPE.

11.7 Spectator Control

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

- 1) appropriate approval from the supervisor has been obtained
- 2) the degree of hazard and avoidance procedure has been explained
- 3) appropriate protective measures are taken

The following table summarizes the administrative and procedural control measures that are normally required for Class 3b and Class 4 lasers and laser systems:

ADMINISTRATIVE AND PROCEDURAL CONTROL MEASURES	CLASSIFICATION	
	3b	4
Standard Operating Procedures	O	✓
Output Emission Limitations	LSO to determine	
Laser Worker Training	✓	✓
Authorized Personnel	✓	✓
Alignment Procedures	✓	✓
Eye Protection, if MPE is exceeded	✓	✓
Skin Protection, if MPE is exceeded	✓	✓
Spectator Control	O	✓
Homebuilt/Modification of Laser Systems	LSO will classify	

LEGEND

- ✓ --- Normally required
O --- Optional

12.0 PROGRAM AUDIT

12.1 The Office of Environmental Health & Safety shall audit various components of the laser safety program (in conjunction with the LSO) on an annual basis and prepare a report to the Laser Safety Committee.

The audit may consist of but is not limited to the following:

- 1) inspections of some Class 3b and Class 4 laser facilities for compliance with the University's Laser Safety Program;
- 2) review of training records to confirm that laser supervisors/workers have had appropriate training to work with Class 3b and Class 4 lasers and laser systems;
- 3) review of medical surveillance records to confirm that laser supervisors/workers have participated in the University's medical surveillance program;
- 4) review of records vs inspections to confirm that the registration/ deregistration process is working effectively.

12.2 A Joint Health and Safety Committee may, as part of its inspection of the workplace and subject to access control procedures, inspect Class 3b and Class 4 laser facilities.

REGISTRATION OF CLASS 3b AND CLASS 4 LASERS

University of Toronto

DEPARTMENT: _____

PRINCIPAL INVESTIGATOR/AUTHORITY: _____

LASER TYPE	PRODUCTION CLASS	LASER CLASS	BUILDING	ROOM #	CONTACT PERSON	USE

Laser Type: CO₂, Nd:YAG, He-Ne, Diode, etc.
Production Class: Commercial, modified, "home-built,"
Laser Class: 3b or 4
Use: Research, medical or therapeutic application, undergraduate teaching, outside user

Please provide the necessary information and **mail to:**

Chris McNeill
Office of Environmental Health & Safety
215 Huron Street, 7th floor
 or **Fax to:** *Chris McNeill at 971-1361*

UNIVERSITY OF TORONTO

Office of Environmental Health and Safety

LASER INSPECTION FORM
Class 3b and Class 4 Lasers and Laser Systems

Inspector: Date of Inspection: Location (Building/Room): Department:
Name of Principal Investigator: Phone # Name of Lab Contact: Phone #
Laser Type: Class: Model # Serial # Production Class:
Other Information:

LASER POSTING, LABELING AND ROOM SECURITY MEASURES:

Entrances properly posted: Y N Comments:
Room security adequate: Y N Comments:
Windows/doorways/open portals in room covered: Y N NR Comments:
Entryway interlock system: Y N NR Comments:
Interlock functioning: Y N NR Comments:
A door, blocking barrier, curtain, etc. at entryway: Y N NR Comments:
Laser status indicator outside room: Y N NR Comments:
Laser class label in place: Y N Comments:
Laser hazard label in place: Y N Comments:

LASER UNIT SAFETY CONTROL MEASURES:

Protective housing in place: Y N Comments:
Interlock on housing: Y N Comments:
Interlock on housing functioning: Y N Comments:
Beam shutter present: Y N NR Comments:
Key control: Y N NR Comments:
Laser activation warning system (with emission delay) in place: Y N NR Comments:
Remote interlock connector (emergency shutoff) available: Y N NR Comments:

ENGINEERING SAFETY CONTROL MEASURES:

Laser secured to table: Y N Comments:
Laser optics secured to prevent stray beams Y N Comments:
Exposed beam path at normal eye level: Y N NR Comments:
Enclosed beam path: Y N Comments:
Limited open beam path: Y N Comments:
Totally open beam path: Y N Comments:
Beam barriers in place: Y N NR Comments:
Beam stops in place: Y N NR Comments:
Beam intensity reduced through filtration: Y N NA Comments:
Remote viewing of beam: Y N Comments:
Reflective materials kept out of beam path: Y N Comments:
Laser user checking for stray beams Y N Comments:
Physical evidence of stray beams: Y N Comments:

Appendix B (Page 2 of 2)

ADMINISTRATIVE AND PROCEDURAL SAFETY CONTROL MEASURES:

Standard Operating Procedures (SOPS) are available: Y N NR Comments: _____
Alignment procedures are available: Y N Comments: _____
Laser operated by authorized personnel: Y N Comments: _____
Excessive power/radiant energy accessible for required application: Y N Comments: _____
Appropriate action taken for spectator control: Y N NR Comments: _____
All supervisors/workers have met the laser safety training requirement as per section 6 of the laser safety program: Y N Comments: _____

Has homebuilt/modified laser/laser system been classified: Y N Comments: _____
Proper laser eye protection available: Y N NR Comments: _____
Proper skin protection available: Y N NR Comments: _____

OTHER SAFETY MEASURES:

All Class 3b/4 lasers and laser systems under the jurisdiction of this PI have been registered as per section 4 of the laser safety program: Y N
Comments: _____
All supervisors/workers have met the laser safety medical surveillance requirement as per section 8 of the laser safety program: Y N Comments: _____

Accident forms are available and accidents are reported as per section 7 of the laser safety program: Y N Comments: _____

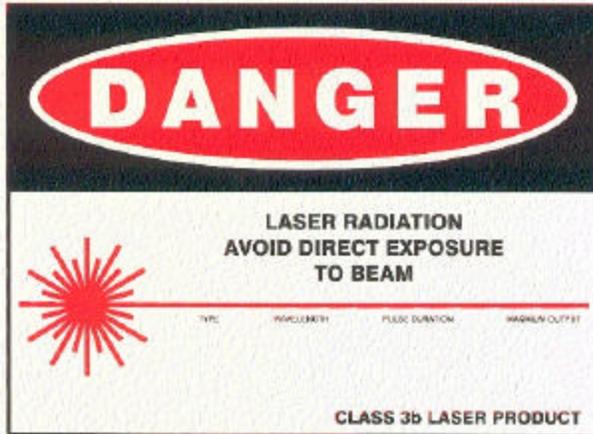
NON BEAM HAZARDS:

Toxic laser media in use: Y N Comments: _____
Hazardous laser media stored properly: Y N Comments: _____
Cryogenics in use: Y N Comments: _____
Compressed gas in use: Y N Comments: _____
Gas cylinders properly restrained: Y N Comments: _____
Fume hood for dye mixing: Y N Comments: _____
Laser Generated Air Contaminant (LGAC) production: Y N Comments: _____
High voltage power hazard: Y N Comments: _____
Other electrical hazards: Y N Comments: _____
Collateral and plasma radiation hazard: Y N Comments: _____
Fire hazard: Y N Comments: _____
Explosion hazard: Y N Comments: _____
Mechanical hazards: Y N Comments: _____
Noise/Vibration hazards: Y N Comments: _____
Proper disposal of chemical wastes: Y N Comments: _____

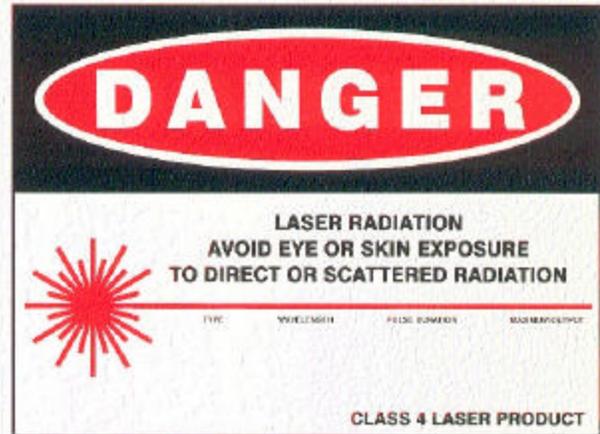
ADDITIONAL COMMENTS:

SUMMARY OF ACTION REQUIRED

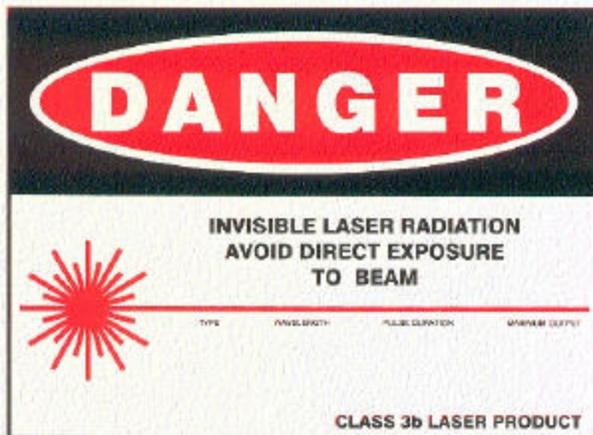
W Acceptable Safety Practices
W Improved Safety Measure(s) Required --- **minor issue(s)** to be addressed
W Improved Safety Measure(s) Required --- **major issue(s)** to be addressed
W Unacceptable Safety Practice(s) --- Requires action by following date(s): _____



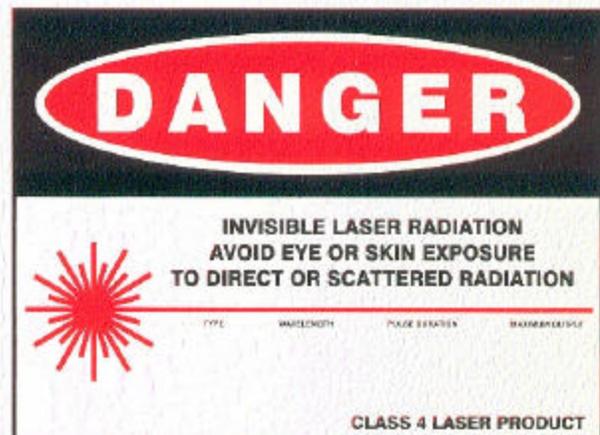
3b-1



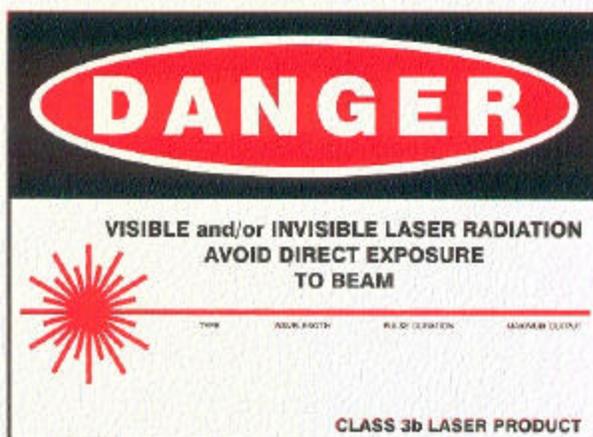
4-1



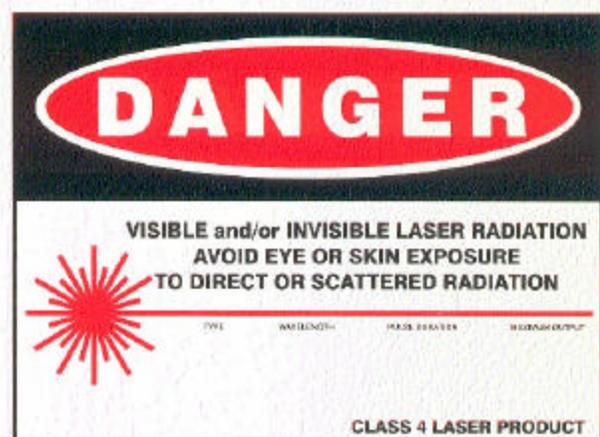
3b-2



4-2



3b-3



4-3