**Guide for Implementing a UBC Laser Safety Program**

**When Using Class 3B and Class 4 Lasers**

Before any work is performed with Class 3b or Class 4 lasers, advance preparation is required to set up equipment, and implement regulatory and administration protocols in order to control the hazards associated with lasers and to maintain exposures at or below Maximum Permissible Exposure (MPE). These requirements are not necessary for work with Class 1 or Class 2 lasers. This document is intended to guide the laser system owner in the creation of a local laser safety program when using Class 3B and Class 4 lasers.

Here are the top items that are required to be completed before any work with lasers has started:

* Risk assessment
* Lab design and layout
* Laser equipment registration
* Standard operating procedures
* Training
* Medical surveillance

Designate Roles:

* Laser facility supervisor
* Purchaser
* Trainer
* Authorized users

**Risk Assessment**

The risk assessment is designed to lead the principal investigator, or laser facility supervisor with the objective of predetermining the necessary control measures prior to the purchase of equipment and start of work.

**Laser Registration**

The facility supervisor is responsible for registering with the SRS Research Safety Office (research.safety@ubc.ca) all Class 3b and Class 4 lasers by filling out and submitting the Laser Registration Form ([UBC Laser Safety, General Information and Registration](https://srs.ubc.ca/health-safety/research-safety/radiation-safety/laser-safety-general-information-registration/)). The purchase of all Class 3b and Class 4 must be only performed by a Principal Investigator or a designate. Acquisitions include gifts, loans, purchases and transfers from external off-campus institutions. The facility supervisor is responsible for notifying SRS in writing of the following changes: laser system changes (e.g., add, delete or dispose of, move, modify etc.) laser locations (e.g., add, delete, renovate, etc.).

**Laboratory Layout**

Class 3b or Class 4 equipment should not be used until the location and laboratory design is reviewed and acceptable to SRS. The figure below shows a suggested layout for Class 3b and Class 4 lasers laboratory. Non-beam hazards such as sufficient power and appropriate ventilation of air contaminants should also be addressed. Appropriate posting of required signs into the laser area should also be addressed.



Legend:

1. Cabinet for safety goggles
2. Fire extinguisher
3. Door interlock override button
4. Danger sign on door
5. Standard operating procedures
6. Only one class 4 laser or laser system in the laboratory
7. Beam stops to prevent laser beam from leaving the optical table
8. Beam tube mounted on the table

**Standard Operating Procedures**

Each laser facility is required to have written standard operating procedures specific to Class 3b and Class 4 lasers. The procedures must be readily available in the laboratory and authorized users must have documented training on the specifics of operating the laser. The standard operating procedures must contain the following information:

* Operating procedures including startup and shutdown
* Nominal Hazard Zone (NHZ)
* Alignment procedures
* Use and type of personal protective equipment
* Maintenance procedures

All laser users are responsible for the safe use of laser equipment and must follow the standard operating procedures. The Laser Supervisor is responsible for establishing the standard operating procedures for Class 3b or Class 4 lasers and ensure that it is followed by all users.

**Training and Registration of Authorized Users**

All laboratory staff working in proximity to the laser facility, from principal investigator to summer student, must receive proper training to work with Class 3b or Class 4 lasers. The facility supervisor must ensure that Class 3b and/or Class 4 users complete all specific hands-on training as well as the laser safety training provided by UBC. All training records and an up to date authorized user list must be kept on hand in the lab. An authorized laser user form is included in the Appendix.

**Medical Surveillance**

All class 3B and class 4 laser supervisors/users/laser laboratory workers are strongly advised to participate in the UBC medical surveillance program. A medical eye examination is recommended to establish a baseline against which damage can be measured in the event of an injury and to identify Class 3b or Class 4 laser users who might be at special risk.

**Control Measures for Class 3b and Class 4 Lasers**

The ANSI Z136 series of laser safety standards provide a detailed description of control measures which can be put into place to protect against potential accidents. Typical controls can be divided into two distinctive categories: engineering and administrative controls. Like any other potentially hazardous operation, lasers can be operated safely through the use of suitable facilities, equipment, and well-trained personnel.

**Engineering Controls**

Engineering controls are generally costlier to develop but are considered far more reliable. Examples include protective housings, system interlocks, key-controls, etc. Commercial lasers will be certified by the manufacturer and will have some engineering controls in place. In some research application some of these engineering controls may be impractical and it will be necessary to use administrative controls to provide protection. A hazard analysis in conjunction with SRS shall be conducted to ensure the safe operation of the laser system.

The following table summarizes the engineering controls measures that are normally required for class 3B and class 4 laser systems.

|  |  |
| --- | --- |
| **Engineering control measures** | Laser Classification |
| 3B | 4 |
| Controlled access | Y | Y |
| Protective housing | Y | Y |
| Without protective housing | SRS to advise |
| Interlocks on protective housing | Y | Y |
| Interlocks on entrance doors | O | O |
| Service panel access only to authorized personnel | Y | Y |
| Key control  | O | Y |
| Viewing portals (reduce light below MPE) | Y | Y |
| Collecting optics (reduce light below MPE) | Y | Y |
| Enclosed beam path | NC | NC |
| Limited open beam path | NHZ | NHZ |
| Completely open beam path | NHZ | NHZ |
| Remote interlock connector | O | Y |
| Beam stop or attenuator | Y | Y |
| Protective Windows | Y | Y |
| Protective Barriers and Curtains | O | O |
| Activation warning systems | O | Y |
| Indoor laser-controlled area | Y | Y |
| Temporary laser-controlled area  | Y | Y |
| LEGENDY ----RequiredO ----OptionalNC ----No further controls requiredNHZ ----Nominal Hazard Zone analysis requiredMPE ---Maximum Permissible Exposure |

**Protective Housing**

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

**Lasers Without Protective Housing**

In some circumstances operation without protective housing may be necessary. In these cases, SRS shall assess the hazard and ensure that appropriate controls are instituted. The controls may include access restriction, barriers, shrouds, beam stops, eye protection, administrative and procedural controls, and training. Other controls may also be required, depending on the hazard assessment.

**Interlocks on Protective Housing**

An interlock system on the protective housing prevents access to the laser radiation above the MPE. It is activated when the protective housing is opened during operation and maintenance. The interlock shall not be overridden during operation unless adequate controls for lasers without protective housing have been established.

**Service Access Panels**

As part of the protective housing, the access panels are intended to be removed by service personnel only. Because they permit direct access to laser radiation, the panels must be either interlocked or require a tool for removal and shall have a warning label.

**Key Control**

A master switch, which is operated by a removable key or by a coded computer access.

**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 (e.g., optical instruments such as lenses, telescopes, microscopes) intended for viewing with a 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 MPE.

**Enclosed Beam Path**

The preferred control method is when the entire beam path is enclosed and the enclosure fulfills all the requirements of a protective housing by limiting the radiation exposure to at or below the MPE. No further controls are required.

**Completely Open Beam Path**

Where the entire beam path is unenclosed, and if the NHZ is not furnished by the manufacturer, a hazard analysis must be established. The analysis will define the area where laser radiation is accessible at levels above the MPE and will define the zone requiring control measures.

**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 continue to be accessible. A hazard analysis is required to establish the NHZ. If the NHZ is limited, then administrative controls may provide adequate protection.

**Remote Interlock Connector**

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

**Beam Stop**

An attenuator (i.e. beam stop) is a device capable of preventing access to laser radiation in excess of the appropriate MPE level.

**Protective Windows, Barriers and Curtains**

All windows, doorways, open portals, etc. from an indoor facility are either covered or restricted in such a manner as to reduce the transmitted laser radiation to levels at or below the appropriate ocular MPE. A door blocking barrier/screen/curtain, 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 the MPE and that no one receives exposure above the MPE immediately upon entry.

**Activation Warning System**

For all Class 4 lasers, 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 is required.

**Indoor laser-controlled area**

When the beam path of a class 3B or class 4 laser or laser system is completely open, a laser-controlled area must be established and adequate control measures must be implemented. This will include engineering controls, administrative controls and PPE that will ensure that there are no exposures above MPE.

**Temporary Laser Controlled Area**

Where removal of panels or protective housings, over-riding of protective housing interlocks and entry into the NHZ becomes necessary such as for service, and the accessible laser radiation exceeds the 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. A notice sign shall be posted outside a temporary laser-controlled area to warn of the potential hazards.

**Administrative Controls**

Administrative controls are designed to supplement engineering controls. The focus of these controls is to provide adequate training, provisions for protective equipment, and procedures related to the operation, maintenance and servicing of the laser. For Class 3b and Class 4 lasers, the following administrative controls and normally required:

**Area Posting**

An area which contains a Class 3b or 4 laser or laser system shall be posted with the appropriate sign. Area signs may be obtained from the SRS.

**Equipment Labels**

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

**Standard Operating Procedures (SOP’s)**

Written SOP’s shall be maintained for reference by the operator, and maintenance personnel. The SOPs may include the laser instruction manual from the manufacturer and as appropriate, additional written information to ensure good work practices. The SOPs should include procedures for experimental set-up, system alignment, routine operation, maintenance.

**Training**

Training shall be provided for operators or service personnel prior to the start of work. The level of training shall be commensurate with the level of potential hazard. All training records must be kept on hand in the lab.

**Authorized Personnel**

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

**Alignment Procedures**

Eye hazards may exist during beam alignment procedures. Written SOP’s outlining alignment methods must be available. Alignment must 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 MPE.

**Spectators**

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

A. Appropriate approval from the supervisor has been obtained.

B. The degree of hazard and avoidance procedure has been explained.

C. Appropriate protective measures are taken.

All the above requirements must be fulfilled in order for spectators to be in a laser-controlled area.

**Personal protective equipment (PPE)**

Enclosure of the laser equipment or beam path is the preferred method of control, since enclosure will isolate or minimize the hazard. If enclosure 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 (PPE) to provide protection against laser radiation.

**Laser eye protection**

Lasers can produce serious injury to the eyes if adequate protection is not worn. A laser eye protection device is a filter which is designed to reduce light transmission of a specific wavelength, or range of wavelengths, to a safe level while maintaining adequate light transmission at all other wavelengths. Eye-protection devices which are specifically designed for protection against the emitted wavelength of the laser should be used when engineering and procedural controls are inadequate.

\*\*\*Note: Even if you are wearing protective eyewear, never look directly into any laser beam

The Principal Investigator must ensure that laser protective eyewear is available and worn by all personnel within the Nominal Hazard Zone of class 3B and class 4 laser/laser systems where the exposures above the MPE can occur.

The Principal Investigator shall provide laser protective eyewear that is clearly labeled with the optical density and the wavelength for which protection is afforded. Laser supervisors/users/laser laboratory workers shall wear protection as required and shall inspect laser protective eyewear for damage prior to use. Faulty eyewear must be identified as not be used and must be replaced as soon as possible. Protective eyewear shall be cleaned periodically, according to the manufacturer's instructions.

**Skin protection**

For class 3B and 4 lasers operating in the ultraviolet range (180 to 400 nm), skin protection must be used if exposures are anticipated at or near the applicable MPE. Types of skin protection would include laboratory coats, tightly woven fabrics, opaque gloves and full-face shields.

**Non-Beam Hazards**

Any existing non-beam hazards must be addressed in a risk assessment. Appropriate engineering, administrative and PPE controls must be adopted for such hazards. Below is a list of the most common non-beam hazards (see Associated Hazards document for more complete descriptions).

* Electrical Safety
* Laser Dyes and Solvents
* Laser generated air contaminants (LGAC)
* Compressed and/or Toxic Gases
* Cryogenic Fluids
* Explosion Hazards
* Non-Beam Radiation
* Ergonomics
* Seismic Safety

**Appendix (Forms and Sample SOP)**

**Authorized Laser User Form**:

|  |  |
| --- | --- |
| Laser Supervisor: |  |
| Phone: |  |
| Laser Location: |  |
| Laser Description (include description of use): |  |
| Name of Authorized User | Date of Laser Training | Procedure |
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**Hazards and Controls Form:**

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| Hazard | Engineering Control | Administrative Control | PPE |
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**Sample Standard Operating Procedure**

* Obtain the interlock key from the Laser Supervisor.
* Ensure that all unauthorized people leave the room.
* Secure the laboratory door then activate the laboratory interlock system. Be ready to turn

 the laser off if any unauthorized person or a person without laser safety eyewear enters

the laboratory.

* Ensure all users remove wristwatches or other reflective jewelry from their bodies.
* Setup the optical component necessary for the experiment.
* Check that all beam stops are in place and that there are no unnecessary reflective

surfaces in the optical path. One block should be placed behind the first optical

component. A second beam stop should be placed behind the second optical

component etc.

* Ensure that appropriate laser safety eyewear is worn by everyone in the laboratory.
* Set the laser power control to the lowest power possible.
* Insert the interlock key into the laser switch and unlock the laser.
* Announce loudly, with a short countdown that you are turning the laser on.
* Turn the laser on.
* Align the optical components starting with the component nearest the laser.
* When it is aligned, move the first beam block behind the third optical component. Repeat

this procedure until the entire optical system is aligned. It is important that the laser

beam be limited to one new component at a time until the system is aligned. This will

minimize uncontrolled reflection during the alignment procedure. If possible the person

making beam alignments should be at right angles to the direction of the beam.

DO NOT REMOVE YOUR SAFETY EYE WEAR DURING THE ALIGNMENT PHASE.

IF YOU CANNOT SEE A FAINT IMAGE OF THE BEAM YOU HAVE THE WRONG OPTICAL

DENSITY EYEWEAR.

TURN OFF THE LASER AND OBTAIN EYEWEAR WITH THE CORRECT OPTICAL

DENSITY.

Increase beam power if necessary and complete the work. Always use the lowest beam power

necessary for the procedure.

* Turn off the laser.
* Remove your laser safety eyewear and place it in their proper storage area.
* Remove the key from the laser interlock switch
* Turn off the laboratory interlock system.
* Return the key to the Laser Supervisor.