Duquesne University
Laser Safety Program

Purpose
This program defines responsibilities and establishes procedures for the safe use of all laser systems. These procedures must be followed and used to ensure the safety of all individuals using lasers in the laboratory.

Scope
This program will cover the follow aspects of laser safety:

- Introduction to Lasers
- Registration of Laser Systems
- Laser Safety Training Requirements
- Responsibilities
- Laser and Laser System Hazards
- Laser Classifications
- Control Measures
- Emergencies and Incident Procedures

Introduction
This document describes the laser safety program for Duquesne University. The purpose of this program is to protect Duquesne University personnel, guests, and property from the hazards associated with laser and laser systems.

The requirements in this program apply to lasers in the class of 3b and 4 only. The hazards from lasers in classes 1, 2, and 3a are less significant than the high-powered lasers in classes 3b and 4. All lasers, regardless of class, can cause injury if misused.

LASER is an acronym which stands for Light Amplification by Stimulated Emission of Radiation. The laser produces an intense, highly directional beam of light. The most common cause of laser-induced tissue damage is thermal in nature, where the tissue proteins are denatured due to the temperature rise following absorption of laser energy.

The human body is vulnerable to the output of certain lasers, and under certain circumstances, exposure can result in damage to the eye and skin. Research relating to injury thresholds of the eye and skin has been carried out in order to understand the biological hazards of laser radiation. It is now widely accepted that the human eye is almost always more vulnerable to injury than human skin.

Registration of Laser Systems
For each laser used on campus a Laser Registration Form will need to be filled out and submitted to the Radiation Safety Office (B-7), Mellon Hall.

Laser Safety Training
Each Principle Investigator (PI) is responsible for providing laser safety training to persons using lasers or entering controlled areas under his or her supervision. Other individuals may provide the training under the supervision of the PI. The nature of training should be commensurate with potential health protection problems in the area.

Responsibilities

Principle Investigators

The primary responsibility for ensuring the safe use of lasers belongs to Principal Investigators (PIs). Specifically, PIs are responsible for ensuring that:

- Only authorized individuals operate lasers or have access to controlled areas during laser operation.
- Individuals authorized to use lasers have received adequate safety training.
- Appropriate Personal Protective Equipment (PPE) is available and worn when necessary.
- Laser operating procedures include adequate safety measures.
- Lasers manufactured or modified are properly classified and labeled.
- Proper laser warning signs are posted.
- All lasers have been registered with the Radiation Safety Officer.

Operators

Persons operating lasers are responsible for:

- Following proper operating and safety procedures.
- Performing only those operations authorized by the PI.
- Restricting access to controlled areas during operations.

Laser Safety Officer

An individual designated as the campus Laser Safety Officer (LSO) has the authority and responsibility to monitor and enforce the control of laser hazards and to effect the knowledgeable evaluation and control of laser hazards.

Radiation Safety Personnel

Members of the Radiation Safety Office are available to provide support in all aspects of laser safety, including:

- Providing training, and/or training materials, to PIs and laser operators.
- Classifying lasers and providing appropriate signs and labels.
- Determining proper protective equipment and other PPE.
- Reviewing operating and safety procedures.

Laser and Laser System Hazards

Eye

Different structures of the eye can be damaged from laser light depending on the wavelength. Retinal burns, resulting in partial or complete blindness, are possible in the visible (400-700 nm) and near infrared (700 – 1400 nm) regions. At these wavelengths, the eye will focus the beam or a specular reflection on a tiny spot on the retina. This focusing increases the irradiance of the beam by a factor of about 100,000.

Laser emissions in the ultraviolet (< 400 nm) and infrared to far-infrared (> 1400 nm) regions are primarily absorbed by and cause damage to the cornea. In the near-ultraviolet range (315 – 400 nm), some radiation reaches the lens of the eye.

Skin

Skin damage can occur from exposure to infrared or ultraviolet light. For infrared exposure, the results can be thermal burns or excessively dry skin depending on the intensity of the radiation. In the 230 –

380 nm range of ultraviolet light, sunburn, skin cancer, or accelerated skin aging are possible. The most damaging region of ultraviolet is 280 – 315 nm, also known as UV-B.

Electrical
Many lasers contain high voltage components, which can present a potentially lethal hazard. Proper lockout procedures should be followed when working on high-voltage components.

Fire
Many class 4 lasers are capable of igniting combustible materials. Care should be taken when selecting beam stops and shielding material.

Hazardous Materials
Laser laboratories contain many of the same hazards found in many chemical laboratories and therefore the same precautions should be taken. In addition, most laser dyes are considered to be hazardous materials and should be handled accordingly. Laser interactions with certain materials may produce toxic fumes, which must be properly vented.

Laser Classifications
Lasers and laser systems are classified by potential hazard according to a system described in the American National Safety Institute (ANSI), Standard Z136.1, and in 21 CFR part 1040. A laser's classification is based on several factors including its wavelength, power output, accessible emission level, and emission duration. The level of hazard associated with each class of lasers is listed below.

Class 1
Lasers in this class are incapable of causing eye damage. These lasers are exempt from labeling requirements.

Class 2
Lasers in this class emit only visible light. They are only capable of producing eye damage if the beam is stared at directly for longer than the normal human aversion response time to bright light (0.25 second). This means a person would naturally turn away from the beam before any damage is done.

Class 3a
Lasers in this class are capable of causing eye damage from short-duration (< 0.25 second) viewing of the direct beam.

Class 3b
Class 3b lasers are capable of causing eye damage from short-duration (< 0.25 second) viewing of the direct or specularly-reflected beam. Diffuse reflections from these lasers are generally not hazardous, except for intentional staring at distances close to the diffuser.

Class 4
Lasers in this class are high powered and capable of causing severe eye damage with short-duration exposure to the direct, specularly-reflected, or diffusely-reflected beam. They are also capable of producing severe skin damage. Flammable or combustible materials may ignite if exposed to the direct beam.

Embedded Lasers

A laser system of one class may contain a laser of a higher class. For example, a 3a system might contain a class 4 laser in an interlocked protective housing which incorporates design features to limit the accessible emission level to the class 3a level.

If a laser or laser system has been manufactured by or modified at Duquesne University, the PI is responsible for determining the laser's proper classification. This classification may be accomplished using tables from ANSI136.1, depending if the laser is pulsed or continuous.

Control Measures

This section describes administrative, procedural, and engineering measures, which can reduce the chance of a laser-related incident. These measures should be considered when evaluating a class 3b or a class 4 laser facility. Although some items are appropriate for all facilities (e.g. posting proper warning signs), others may not be practical for some operations. Primary control measures are *italicized* for emphasis. In most cases, implementing these measures will provide the most effective safety considerations.

Beam Control

Enclosure of the laser equipment or beam path is the preferred method of control, since the enclosure will isolate or minimize the hazard. As a minimum, beam stops must to be used to ensure no direct or specularly reflected laser light leaves the experiment area.

Laser beams height should be maintained at a level other than the normal position of the eye of a person in the standing or seated position. Securely fasten the laser and all optics on a level, firm, and stable surface.

Reflections

Remove unnecessary reflective items from the vicinity of the beam path. Do not wear reflective jewelry such as rings and watches while working near the beam path.

Be aware that lenses and other optical devices may reflect a portion of the beam from their front or rear surfaces.

Avoid placing the unprotected eye along or near the beam axis. The probability of a hazardous specular reflection is greatest in this area.

Power Level

The minimum laser radiation required for the application should be used. Operate a laser at the minimum power necessary for any operation. Beam shutters and filters can be used to reduce the beam power. Use a low power laser when possible during alignment procedures.

Signs and Labels

The entrance to a class 3b or class 4 laser facility most be posted with the appropriate warning sign. Each laser must be labeled as required by 21 CFR part 1040. These labels show the classification of the laser and identify the aperture(s) where the laser beam is emitted. Signs and labels may be obtained through the Radiation Safety Office.

Warning Devices

Class 4 laser facilities where the beam is not fully enclosed should have a visible warning device (e.g. flashing red light) at the outside of the entrance, which indicates when the laser is in operation.

Control of Area
Except for fully closed and interlocked systems, an authorized user must be present or the room kept locked during laser operations.

Interlocks
Many laser systems have interlocked protective housing which prevents access to high-voltage components or laser radiation levels higher than those accessible through the aperture. These interlocks should not be bypassed without the specific authorization of the PI. Additional control measures must be taken to prevent exposure to higher radiation levels or high voltage while the interlock is bypassed.

Personal Protective Equipment
Eye protection designated for the specific wavelength of laser light should be available and worn when there is a chance that the beam or a hazardous reflection could reach the eye. The manufacturer should mark protective eyewear with the wavelength range over which protection is afforded and the minimum optical density within that range. Eyewear should be examined prior to each use and discarded if there is damage which could reduce its effectiveness.

Protective eyewear generally will not provide adequate protection against viewing the direct beam of a high-powered laser. Wearing protective eyewear should not be used as an excuse for performing an unsafe procedure.

Training
All operators must receive training in the safe and proper use of lasers by the PI (or a person designated by the PI) before being allowed to operate a laser.

Operating Procedures
Written operating procedures should be available which include applicable safety measures.

Maintenance/Service
Only a knowledgeable person who has been specifically authorized by the PI to perform such work should perform maintenance, servicing, or repair of the laser. Whenever such work involves accessing an embedding laser of a higher class, the controls appropriate to the higher laser must be applied.

Any laser, which is significantly modified, must be re-evaluated to determine its classification.

Emergencies and Incident Procedures

Emergencies
For all emergencies requiring the campus police, fire, or ambulance assistance, call x2677.

Emergencies or Incidents Involving Lasers
In the event of an accident or an unusual incident involving a laser: TURN OFF THE LASER.

If there is a serious injury or fire, call x2677 and request paramedics or the fire department.

Notify the Radiation Safety Office (x6382) of any occurrence. If after working hours, contact the campus police (x2677) and have the operator contact an EHS representative.

Notify the laboratory supervisor or the PI.