Laser Safety and Regulations

Division of Chemistry and Biological Chemistry,
School of Physical and Mathematical Sciences
Nanyang Technological University

INTRODUCTION

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

In general, it is the responsibility of the individual laser user to understand and conduct operations in an acceptable manner to minimize hazards to self and others. All individuals using radiation sources must familiarize themselves with all information herein and apply to their operations. Persons operating lasers are responsible for:

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

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 of the 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, erythema (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 choosing 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

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 visible light only. 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 (<0.25s) viewing of the direct beam.

CLASS 3b

Class 3b lasers are capable of causing eye damage from short-duration (<0.25s) 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 class 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.

CONTROL MEASURES

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 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 jewellery such as rings or 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 lower power laser when possible during alignment procedures.

SIGNS AND LABELS

The entrance to a class 3b or 4 laser facility must be posted with the appropriate warning sign. Each laser must be labelled. These labels show the classification of the laser and identify the aperture(s) where the laser beam is emitted.

WARNING DEVICES

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

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CONTROL OF AREA

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

INTERLOCKS

Many laser systems have interlocked protective housings which prevent 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 the higher radiation levels or high voltage while the interlock is bypassed.

PERSONAL PROTECTIVE EQUIPMENT

Eye protection designed 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 a laser. Whenever such work involves accessing an embedded laser of a higher class, the controls appropriate to the higher class must be applied.

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

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EMERGENCIES AND INCIDENT PROCEDURES

In the event of an accident or unusual incident involving a laser: TURN OFF THE LASER. Report **immediately** to the laboratory supervisor or PI.

Emergency Numbers:

Fire/Ambulance	995
Police	999
NTU Campus Security	6790-5200
CBC Building Manager	6513-8191

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I,_____, NRIC/FIN _____ do hereby acknowledge that I have read the Laser Safety Regulations (Aug 2009 edition, CBC, SPMS, NTU) and watched the online laser safety video[i]. I understand and appreciate fully the risks, hazards and dangers involved in the engagement of laser work aforementioned.

I am fully aware that I am responsible for my personal safety and those around me. I am to conduct operations in an acceptable manner to minimize hazards to self and others.

Date this _____

Signed: _____

(Please also sign at the bottom of every page of this document)

[i] http://www.coherent.com/downloads/laser-safety-video.wmv