Rosalind Franklin University

Laser Safety Manual

Emergency Reference Numbers:

Police, Fire, or Ambulance …… 9-911

Radiation Safety ……. x-3446

Dr. Daniel Peterson, Laser Safety Officer (LSO) …….. x-3411, 3501

Security …….. x-3288

Office of Environmental Health and Safety (OEH&S)
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Laser Safety Manual

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Registration of Laser Systems

The Illinois Emergency Management Administration (IEMA) requires that all Class 3b or 4 laser systems be registered with the State. The Radiation Safety Section can provide this registration process.

To register a laser, obtain a copy of the Laser Registration on line from the Office of Environmental Health & Safety (OEH&S) website. Provide full and complete responses to the application and submit it to the OEH&S, Attn: Judy Ptasienski. The Radiation Safety Office will ensure the laser system is registered with IEMA.

Laser Safety Training Requirements

Each Principal 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 OEH&S will provide general training to personnel annually.

The nature of the training should be commensurate with the potential health protection problems in the area.

PRINCIPAL INVESTIGATORS

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

- Only authorized individuals operate lasers or have access to controlled areas during laser operations.
- Individuals authorized to use lasers have received adequate 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 class 3b and 4 lasers have been registered with OEH&S.

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 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 OEH&S 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 eyewear and other PPE.
- Reviewing operating and safety procedures.

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

Lasers and laser systems are classified by potential hazard according to a system described in the American National Standards 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 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 (0.25x) 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.

If a laser or laser system has been manufactured by or modified at RFUMS, the principal investigator is responsible for determining the laser's proper classification. Contact OEH&S for assistance in making this classification.

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 3 or 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 be used to ensure no direct or specularly reflected laser light leaves the experiment area.

Laser beams height should be maintained as 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 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 ear.

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 labeled as required by 21 CFR part 1040. These labels show the classification of the laser and identify and aperture(s) where the laser beam is emitted. Signs and labels may be obtained through the Radiation Safety Section.

WARNING DEVICES

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

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 Principal Investigator. 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 where 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. In addition, a copy of this Laser Safety Manual should be posed in every room with a class 3b or higher laser.

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.

EMERGENCIES

For any emergency requiring police, fire or ambulance assistance call 9-911. Notify university security (x-3288) as soon as possible afterwards.

EMERGENCIES OR INCIDENTS INVOLVING LASERS

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

If there is a serious injury or fire, call 9-911 and request paramedics or the fire department or contact Campus Security x-3288.

Notify the OEH&S x-3446 or Laser Safety Officer x-3411, 3501. After working hours contact Campus Security x-3288.

Notify the laboratory supervisor or Principal Investigator.

Glossary

Accessible Emission Level (AEL)
The magnitude of laser radiation to which human access is possible. Usually measures in the watts for continuous wave lasers and in joules for pulsed lasers.

Accessible Emission Limit
The maximum accessible emission level permitted within a particular class.

Aperture
An opening through which laser radiation can pass. This term usually refers to the opening on the laser (or a protective housing) where the beam is emitted.

Aversion Response
Movement of the eyelid or the head to avoid exposure to a bright light. For laser light, this response is assumed to occur within 0.25 second.

Continuous Wave (CW) Laser
A laser which has a continuous output for greater than or equal to 0.25 second.

Controlled Area
An area where the occupancy and activity of those within are subject to control and supervision for the purpose of protection from hazards.

Diffuse Reflection
A reflection where different parts of the beam are reflected over a wide range of angles, such as when hitting a matted surface.

Embedded Laser
A laser with an assigned class number higher than the classification of the laser system in which it is incorporated, where the system's lower classification is appropriate because of the engineering features limiting accessible emission.

Enclosed Laser System
Any laser or laser system located within an enclosure which does not permit hazardous optical radiation emission from the enclosure.

Erythema
Redness of the skin due to congestion of the capillaries.

Fiber Optics
A system of flexible quartz or glass fibers which internal reflective surfaces that pass light through thousands of glancing (total internal) reflections.

Fluorescence
The emission of light of a particular wavelength resulting from absorption of energy typically from light of shorter wavelengths.

Infrared Radiation (IR)
Invisible electromagnetic radiation with wavelengths which lie within the range of 0.70 to 1000 micrometers.

Irradiance or Intensity
The optical power per unit area reaching a surface (W/cm^2).

Laser
A device which produces an intense, coherent, directional beam of light. Also an acronym for Light Amplification by Stimulated Emission of Radiation.

Laser System
An assembly of electrical, mechanical, and optical components which includes a laser.

Optical Density (OD)
A logarithmic expression for the attenuation produced by an attenuating medium, such as an eye protection filter. OD = log 10 (I_1/I_1) where I_1, is the incident irradiance and I_1 is the transmitted irradiance.

Protective Housing
A device designed to prevent access to radiant power or energy.

Pulsed Laser
A laser that delivers its energy in the form of a single pulse or a train of pulses, with a pulse duration of less than 0.25 x.

Scanning Laser
A laser having a time-varying direction, origin or pattern of propagation with respect to a stationary frame of reference.

Specular Reflection
A mirror-like reflection. The exact definition of a specular surface is one in which the surface roughness is smaller than the wavelengths of the incident light.

Tunable Laser
A laser system that can be "tuned" to emit laser light over a continuous range of wavelengths or frequencies.

Ultraviolet (UV) Radiation
Electromagnetic radiation with wavelengths between soft X-rays and visible violent light, often broken down into UV-A (315-400 nm), UV-B (28-315 nm), and UV-C (100-280 nm).

Visible Radiation (light)
Electromagnetic radiation which can be detected by the human eye. It is commonly used to describe wavelengths which lie in the range between 400 nm and 700 nm.

Wavelength
The length of the light wave, usually measured from crest to crest, which determines its color. Common units of measurement are the micrometer (micron) and the nanometer (nm).