Weill Cornell Medicine
Medical Health Physics

Laser Safety Program

1.0 Overview

The Laser Safety Program at Weill Cornell Medicine (WCM) is overseen and administered by WCM Medical Health Physics, and has been established to promote a safe work environment for employees who work with or in an area where lasers are present.

The Laser Safety Program is a part of the WCM/NYP Radiation Safety program. As such, laser use is under the general direction and authority of the Laser Safety Officer.

2.0 Table of Contents

3.0 Objective

This program is intended to provide general laser safety information and establish procedures for the safe use of lasers by Weill Cornell Medicine faculty, staff, and students. The procedures described in this Laser Safety Program are designed to identify hazards and to limit exposure to lasers.

4.0 Applicability

This Laser Safety Program applies to WCM faculty, students, and employees who work with or in an area where lasers are present.

WCM Medical Health Physics
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5.0 Roles and Responsibilities

5.1 LASER SAFETY OFFICER (LSO)

The Laser Safety Officer (LSO) is a member of the Medical Health Physics (MHP). LSO duties include:

- Develop the Laser Safety Program and make revisions as needed.
- Review and approve laser safety use at WCM.
- Determine the classification of non-commercial embedded laser systems.
- Provide guidance and assistance to laser users.
- Investigate reports of laser accidents and ensure any necessary corrective actions are taken.

5.2 MEDICAL HEALTH PHYSICS (MHP)

The Medical Health Physics (MHP) will:

- Assist the WCM community in the implementation of this Laser Safety Program.
- Provide Laser Safety Training for laboratories or groups upon request.
- Conduct periodic inspections of laser systems and ensure they are in compliance with applicable regulations.
- Maintain an inventory of Class 3B and Class 4 lasers and laser systems.

5.3 LABORATORY MANAGERS AND PRINCIPAL INVESTIGATORS (PIS)

Laboratory Managers and PIs must:

- Develop and implement policies and procedures in compliance with this program.
- Ensure that all laboratory personnel are aware of and compliant with these policies and procedures.
- Read and comply with this Program.
- Be familiar with the Laser Safety Guide [Class 3B, 4] and ANSI Standard Z136.1
- Train all users on the safe use of all lasers relevant to their duties.
- Provide adequate supervision of all laser users.
- Notify MHP of any changes to SOPs.
- Notify MHP of any changes to enclosed laser systems.
- Post appropriate signage.
- Report accidents/injuries to WCM / NYP Occupational Health and Safety (OHS) and WCM Medical Health Physics (MHP) within 24 hours.

5.4 5.4 LABORATORY PERSONNEL

Lab employees are required to:

- Follow policies and procedures outlined in this plan, as well as those developed by Laboratory Manager and/or PI.
- Notify the Laboratory Manager / PI of any deviations to this Laser Safety Program, or to specific Standard Operating Procedures.
- Request additional information and/or training as needed.

6.0 Lasers Non-Ionizing Radiation

The laser is a device that produces a very intense and very narrow (collimated) beam of electromagnetic radiation in the frequency range of 200 nm (nanometers, 1 x 10-9 meters) to 1 mm. This radiation is generally in the form of intense visible light. Laser light is not an ionizing type of radiation (i.e., not like gamma rays, x-rays, or beta particles); therefore, interaction with the body is generally at the surface.

The eye and the skin are critical organs for laser radiation exposure, and the resultant effects vary depending on the type of laser (frequency or wavelength of the radiation) and beam energy output. Laser energy of the proper wavelength and energy may be focused by the lens of the eye onto the retina, causing severe damage. If laser radiation is of high enough energy, skin burns may also result if extremities or other body parts are placed in the laser beam.

The following table summarizes the various regions of the electromagnetic spectrum produced by laser, and the organs of concern if exposure occurs.

Table 6-1: Electromagnetic Spectrum Lasers

EM Region	Wavelength	Organ Affected
Ultraviolet	200 to 400 nm	Cornea, Lens, Skin
UV-C	200 to 280 nm	All absorbed in Cornea and Conjuctiva
UV-B	280 to 315 nm	Almost all absorbed in Cornea and Conjuctiva Risk of Cataract Formation
UV-A	315 to 400 nm	All absorbed in Lens Risk of Cataract Formation
Visible Light	400 to 780 nm	Retina
Near-Inferred	780 nm to 14 um	Retina, Lens, Skin
Mid and Far IR		
IR-B	1.4 to 3.0 um	Cornea and Skin
IR-C	3.0 um to 1 mm	Cornea and Skin

7.0 Laser Classification Levels

The American National Standards Institute (ANSI) categorizes laser systems into four classifications. These classifications are based on the potential for the direct beam or reflected beam to cause biological damage to the eyes and/or skin.

- **Class 1:** A class 1 laser is safe under all conditions of normal use. This means the maximum permissible exposure (MPE) cannot be exceeded. This class includes high-power lasers within an enclosure that prevents exposure to the radiation, and that cannot be opened without shutting down the laser. For example, a continuous laser at 600 nm can emit up to 0.39 mW, but for shorter wavelengths, the maximum emission is lower because of the potential of those wavelengths to generate photochemical damage. The maximum emission is also related to the pulse duration in the case of pulsed lasers and the degree of spatial coherence.

- **Class 1M:** A Class 1M laser is safe for all conditions of use, except when passed through magnifying optics such as microscopes and telescopes. Class 1M lasers produce large-diameter beams, or beams that are divergent. The MPE for a Class 1M laser cannot normally be exceeded, unless focusing or imaging optics are used to narrow the beam. If the beam is refocused, the hazard of Class 1M lasers may be increased and the product class may be changed. A laser can be classified as Class 1M if the total output power is below class 3B, but the power that can pass through the pupil of the eye is within Class 1.

- **Class 2:** A Class 2 laser is safe because the blink reflex will limit the exposure to no more than 0.25 seconds. The classification only applies to visible-light lasers (400-700 nm). Class-2 lasers are limited to 1 mW continuous wave; or more if the emission time is less than 0.25 seconds or if the light is not spatially coherent. Intentional suppression of the blink reflex could lead to eye injury. Many laser pointers are class 2.

- **Class 2M:** A Class 2M laser is safe because of the blink reflex if not viewed through optical instruments. As with class 1M, this applies to laser beams with a large diameter or large divergence, for which the amount of light passing through the pupil cannot exceed the limits for class 2.

- **Class 3R:** A Class 3R laser is considered safe if handled carefully, with restricted beam viewing. With a class 3R laser, the MPE can be exceeded, but with a low risk of injury. Visible continuous lasers in Class 3R are limited to 5 mW. For other wavelengths and for pulsed lasers, other limits apply.

- **Class 3B:** A Class 3B laser is hazardous if the eye is exposed directly, but diffuse reflections such as from paper or other matte surfaces are not harmful. Continuous lasers in the wavelength range from 315 nm to far infrared

are limited to 0.5 W. For pulsed lasers between 400 and 700 nm, the limit is 30 mJ. Other limits apply to other wavelengths and to ultrashort pulsed lasers. Protective eyewear is typically required where direct viewing of a class 3B laser beam may occur. Class-3B lasers must be equipped with a key switch.

- **Class 4:** Class 4 lasers include all lasers with beam power greater than class 3B. Class 4 lasers pose significant eye hazards with potentially devastating and permanent eye damage as a result of direct beam viewing. Diffuse reflections are also harmful to the eyes within the distance called the Nominal Hazard Zone. Class 4 lasers are also able to cut or burn skin.
- In addition, these lasers may ignite combustible materials, and thus represent a fire risk, in some cases. Class 4 lasers must be equipped with a key switch.

Some Class 2, 3, or 4 lasers that are operated in a lower classification mode and laser systems contained in a protective housing may be authorized at a lower classification. Specific control measures may be required to maintain the lower classification. For embedded systems that are of non-commercial design and construction, the LSO will determine the classification.

For the purposes of laser safety, a direct laser beam that has been deflected from a mirror or polished surface is considered to be as intense as the direct beam. Laser beams that hit flat or non-mirror like surfaces are considered to be diffuse, and the diffusely reflected beam is not as intense or as well defined as the direct beam.

8.0 Safety Guidelines for Laser Operation

The following guidelines may or may not be applicable for each type of laser installation. For example, a Class 4 laser placed into a properly constructed enclosed beam path system may be reclassified as Class 1 or 2, and the required safety measures would then be reduced.

All lasers should use the minimum amount of laser radiation possible to accomplish the experimental objective. Adjust beam height so that it is at a level other than that of a seated or standing person.

Always avoid direct exposure of the eye by a laser beam, no matter how low the power.

6.1 8.1 CLASS 1 LASER CONTROL MEASURES

Control measures or warning labels are not required for Class 1 lasers, although needless direct exposure of the eyes should be avoided.

6.2 8.2 CLASS 2 LASER CONTROL MEASURES

An appropriate warning label must be placed on the housing of the Class 2 laser / laser system. Do not stare into the beam or allow other persons to do so.

6.3 8.3 CLASS 3R OR 3B LASER CONTROL MEASURES

- The laser must have a protective housing such that laser light emerges from the aperture only.
- A key switch interlock system should be used to prevent unauthorized use of the laser.
- The direct or mirror-reflected beam should not be viewed with the naked eye or with optical instruments such as telescopes.
- Do not align the beam with the naked eye.
- A beam stop must be provided to adequately stop the beam with the absence of scattered light emission.
- Protective eyewear may be necessary.
- Spectators must be limited.
- The laser system should be installed in a sole use laboratory and the door kept closed during operation.
- Scattered laser radiation must not escape through a window to the outside.
- High-voltage areas must be labeled and investigated for other associated hazards.

6.4 8.4 CLASS 4 LASER CONTROL MEASURES

All of the measures outlined above for Class 3A and Class 3B lasers should be followed, in addition to the measures below.

- Protective eye wear is required when such systems are in operation.

- Spectators are prohibited.
- Systems must be in sole use areas.
- Keyed access to both the room and the power panel to the laser shall control access to such lasers. The Principal Investigator will keep the key and control access to the area.
- The Laser Safety Officer may institute additional control measures as deemed necessary for the safe operation of the laser.

9.0 Personal Protective Equipment (PPE)

6.5 9.1 PROTECTIVE EYE WEAR

Eye protection is crucial for Class 3b and Class 4 lasers. Eye protection with low optical density (OD) may be desired for the lower classes when they are in a fixed position, such as Class 3R alignment lasers. The LSO will assist with eyewear selection.

Note: eye protection is generally not designed to withstand the direct hit of a high-powered Class 4 beam. Pulsed lasers can have extremely high peak powers and cause instant eyewear failure. Engineering controls are the first line of defense, personal protective equipment is a protection of last resort. Users must take precautions to prevent direct beam exposures.

Recent studies have shown that the optical density of protective eyewear is lower than advertised for ultrafast lasers (especially, for example, pulses < 100 fs). These concerns have not yet been addressed by the ANSI standards used in the US. However, the European standard EN207 does include specifications.

6.6 9.2 SKIN

For UV lasers, skin exposure is a concern for sunburn-like effects and an increased risk of skin cancer. When UV scatter cannot be reduced by shielding, other forms of skin protection must be used. Chemical face shields can block all scattered mid to far UV, while lab coats and gloves can reduce exposure to the rest of the body.

10.0 Standard Operating Procedures (SOPs)

Standard Operating Procedures are recommended for all Class 4 lasers **(see Section 5.3).**

11.0 Hazard Warning Labels/Signs

Entrances to laser areas must be secured against persons accidentally being exposed to beams, and have proper warning signage or labeling posted as required by ANSI Standards. The PI is responsible for posting signs and informing laboratory personnel.

When a Class 3b or 4 laser is left on and personnel want to leave the room, the door must be locked. All windows, doorways, and portals should be covered or restricted to reduce transmitted laser beam below the Maximum Permissible Exposure (MPE).

For Class 4 lasers that have open beam lines, the ANSI Standards require interlocked doors, sensors, pressure sensitive doormats, or devices that turn off or attenuate the laser beam in the event of unexpected entry into the area. However, under special conditions where an interlocked door could interfere with the proposed research activity, an alternate method of protection (such as a curtain or a barrier) should be discussed with OHP to provide a suitable barrier just inside the door or where ever most appropriate to intercept a beam or scatter it, so that a person entering the room will not be exposed above the MPE limits.

12.0 Purchasing Lasers / Laser Systems

The PI shall complete the laser registration form for new lasers, existing lasers, and lasers transferred to WCM that are to be included in the laser inventory.

If a Class 3b or Class 4 laser is fabricated in the lab, the PI shall send an updated laser registration form describing the changes made. The PI shall also keep a copy of the laser registration form in their lab. MHP maintains a laser inventory.

13.0 Moving Lasers / Laser Systems

The PI shall report to MHP any lasers that are transferred to another laboratory at WCM, in order to update the MHP database. The laser systems that are purchased (or those that are built in a R&D lab and transferred to other users out of

WCM) must meet the federal certification requirements. **PIs must ensure that federal certification requirements for laboratory-built lasers are met.**

Note: The transfer of a Class 3b or Class 4 laser on campus to a person who does not have appropriate training, who does not understand the hazards of the laser, and/or who does not have the proper PPE, could result in serious injury. Consult OHP for information on laser hazards, proper safeguards, and the necessary training.

14.0 Laser Disposal

New York State requires that all lasers for disposal must be made inoperable. Acceptable methods include:

- Cutting off power cords
- Disconnecting and separating power supplies from laser head or modules

Certain types of research activities with lasers use organic solvents and toxic dyes. All waste mixtures must be collected and disposed of as hazardous waste through EHS. Collect waste solvent/dyes in compatible containers (usually polypropylene) and label with a hazardous waste label as soon as the first material is added to the container. **Do not attempt to evaporate waste in a fume hood to reduce the volume, or to dispose of the waste down the drain.**

15.0 Laser Accidents / Exposures

Report accidents/injuries to WCM / NYP Workforce Health Safety and WCM Office of Health Physics (OHP) within 24 hours.

In the event of an actual or suspected injury, a medical exam should be performed as soon as practical, ideally within 24 hours. Suspected retinal damage should be inspected by an ophthalmologist.

16.0 References

- American National Standard for Safe Use of Lasers, ANSI Z136.1-2007, The Laser Institute of America, 2007
- OSHA Guidelines for Laser Safety and Hazard Assessment. STD 01-05-001 [Pub. 8-1.7] (1991, August 5)