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Laser Safety Guide

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MIT EHS
ENVIRONMENT · HEALTH · SAFETY

Delegation of Authority

MIT has a standing institute **Committee on Radiation Protection** to oversee all uses of radiation at the Institute and its associated off campus locations. The Committee gives the RPP authority to stop any experiment or process involving radiation that is deemed unsafe.

Massachusetts Department of Public Health regulate the use of radiation sources including lasers. They perform unannounced inspections of laser facilities.

Radiation Protection Program (RPP) acts as the RPC's operational arm by serving the institute through training, oversight/risk assessment of laser use, and providing day to day support for all matters pertaining to lasers.

Principle Investigators (PI), Lab Supervisors (LS), and Lab Representatives (LR) work with RPP to develop and maintain a safe work environment in the laser lab.

How to Dispose of a Laser

For Class 3B and Class 4 laser(s) and laser system(s):

1. Contact RPP to discuss decommissioning plans.
2. Remove all means of activating the laser (electrically deactivated) or destroy the laser (rendered inoperable).
3. Review manufacturer laser manual for a complete list of hazardous materials within the device.
4. Remove and properly dispose of any hazardous materials such as mercury, batteries, oils, dyes, Beryllium oxide (BeO) or other chemicals that are contained in the laser system.
5. Contact RPP for decontamination verification and final disposal options for the laser system.
6. Remove MIT Property tag from the system and contact the Facilities department for disposal assistance.

Registration Process

Laser Registration for Class 3B and Class 4 lasers and laser systems

Follow these steps:
1. Complete form A: Laser Registration
2. Complete form B: Laser Inventory
3. Complete form C: Safety Procedure
4. RPP will perform a Hazard Assessment

***To register a laser with RPP**, and more, visit the laser safety webpage at*
ehs.mit.edu/radiological-program/laser-safety/

Laser Safety Procedure

- The Laser Safety Procedure (LSP) is a short guidance document outlining the safe use of the laser.
- This procedure will include laser control measures, access control, and Laser Eyewear requirements as a minimum,
- It should also include alignment procedures (when applicable).
- All personnel working with this laser must follow this procedure. The LSP is part of the laboratory specific training.
- **This is required for all Class 3B and Class 4 Laser systems**

REMEMBER, the person operating the laser has the primary responsibility for ALL hazards associated with its use.

For outdoor propagation, contact RPP

Laser Classification Summary

Class 1* Incapable of causing injury during normal operations

Class 1M Incapable of causing injury during normal operations unless collecting optics are used

Class 2 Visible lasers incapable of causing injury in 0.25s.

Class 2M Visible lasers incapable of causing injury in 0.25s unless collecting optics are used (typically <1mW)

Class 3R Eye hazard for chronic viewing or use of collecting optics (typically 1-5 mW)

Class 3B Eye and skin hazard for **direct beam** exposure (5-500 mW).

Class 4 Eye and skin hazard **for direct beam and scattered radiation**; also a fire hazard (>500 mW)

***Any laser can be reclassified as a Class 1 with proper enclosures installed and safeguards in place.**

Training Requirements

All Laser Users must complete the following training:
- Laser Safety Training — EHS00371
- Laser Laboratory Specific Training given by an experienced member in the lab
- Follow the Laser Safety Procedure (LSP)

Emergency Procedures

Follow emergency procedures established in the LSP

- **Disable machine** (Emergency Off, shut-down, unplug)
- **Seek medical attention** (if needed) - Dial 100 or 617-253-1212 (cell)
- **Contact Radiation Protection** for an incident review

Safe Work Practices

- **Never** intentionally look directly into laser light.
- Do not fight the eye's blink or aversion response.
- **Never** direct the beam toward people or doors.
- **Never** allow a laser beam to escape from its designated area of use.
- **Remove all unnecessary reflective objects** from the area near the beam path. This may include watches, jewelry, or tools.
- Position the laser so that it is **well above or below eye level** (both standing and sitting).
- When not in use, a laser should be stored to **prevent unauthorized use.**

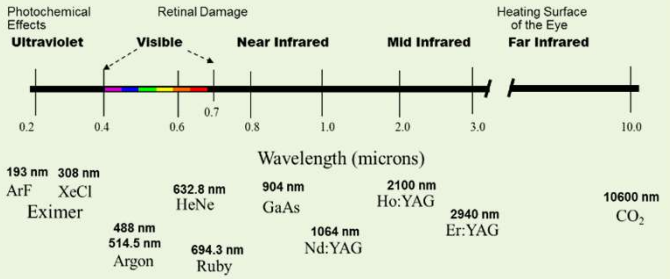
Laser Characteristics

Beam Characteristics

- Wavelength
- Divergence
- Diameter
- Fiber Optics
- Pulse Repetition Rate
  - Continuous ≥ ¼ sec
  - Pulsed < ¼ sec

Active Medium

- Gas
- Solid State
- Diode
- Dye
- Fiber Laser

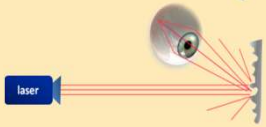


Laser Hazards

Primary Beam Hazards
Intrabeam viewing

Scattered Beam Hazards
Specular reflection

Diffuse reflection (Class 4 only)



Most Hazardous Act – Beam Alignment
Estimated ~1/3 of all (known) accidents, ~ 60 -70 % of all known laboratory accidents.
Common Scenario: unanticipated reflection from an optic while not wearing protective eyewear
Non-Beam Hazards
- Electrical (Keep equipment off the floor)
- Fire (irradiances exceeding 10 W/cm^2)
- Chemical (Excimer and dye lasers)
- Laser generated airborne contaminants

Laser Eye Protection (LEP)

The optical density (OD) of LEP represents an order of magnitude reduction of the laser light reaching the eye

$$OD = log_{10}\left[\frac{H_0}{MPE}\right]$$

All LEP must be labeled

LEP Inspection

- **Match eyewear to laser** (OD and Wavelength)
- **Inspect the lens** (white marks, blemishes, pits/digs, surface scratches, coating tack)
- **Inspect the frame** (broken, cracked, loose strap)
- **Evaluate the fit** (gaps between frame and face)

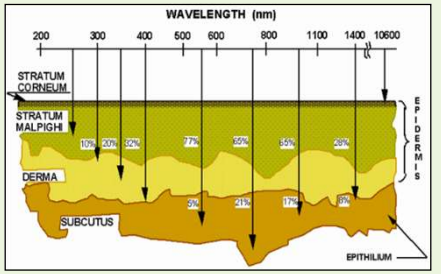
Laser Safety Terminology

Maximum Permissible Exposure (MPE):
The level of laser radiation to which a person may be exposed without experiencing hazardous effect or adverse biological changes in the eye or skin.
Accessible Emission Limit (AEL):
Allowed emission within a certain laser hazard class.
Nominal Hazard Zone (NHZ):
The space within which the irradiance or radiant exposure exceeds the appropriate MPE.
Nominal Ocular Hazard Distance (NOHD):
The distance along the axis of the unobstructed beam from a laser, fiber end, or connector, to the human eye beyond which the irradiance or radiant exposure is not expected to exceed the MPE.

Biological Response

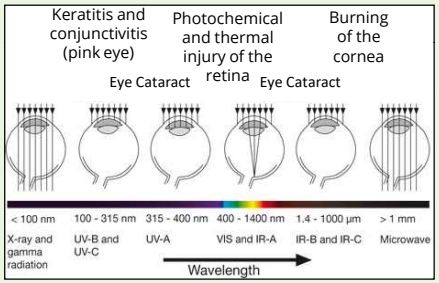
Skin Injury:

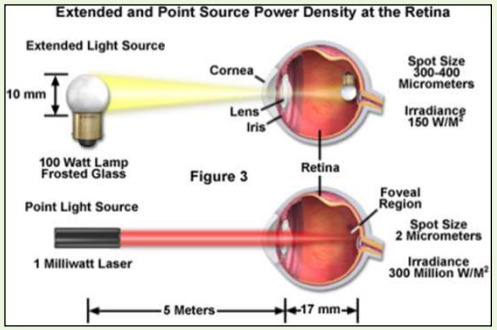
All Wavelengths:
Thermal, Skin Burns
For <550 nm:
Photochemical, skin cancer, "tanning", photosensitive reactions (can be medication related)



Eye Injury:

See: Flash or after image in opposite color OR difficulty detecting blue or green colors
Feel: Burning pain on cornea
Hear: "Pop" sound





A 100 Watt light bulb has 100,000 times the power of a 1 mW laser. The same laser is 2-10 million times brighter.

Hazard Assessment

- Contact the Radiation Protection Program after obtaining any new laser systems.
- The Laser Safety Officer (LSO) will evaluate the LSP and perform a Hazard Assessment of the lab, verify required eyewear, and supply the lab with proper signage.

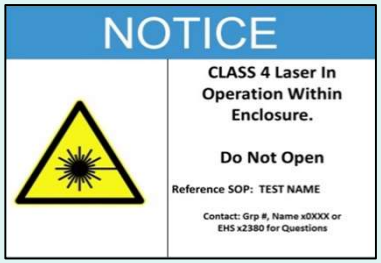
Emergency Power Off

- An Emergency Power Off (EPO) for the laser system is **REQUIRED for Class 4 Systems**.
- The EPO must be labeled and ideally should be located on the laser table or at table level.
- SOP must state what the EPO controls.

Posting Requirements

NOTICE signs are required for all ***temporary*** laser system setups including alignments.

DANGER signs are laser-specific and must be posted at the lab entry point.



Controlled Area Requirements

- Only individuals trained in laser safety are allowed access to the laser controlled area (**Class 4 only**).
- Use only diffusely reflecting materials in or near the beam path.
- Secure the laser beam path to be above or below eye level.
- Facility is under the direct supervision of an individual knowledgeable in laser safety.
- Access is limited and requires approval to enter.
- Store lasers in a manner that prevents the unauthorized use.
- Light tight room (depends on system – **required for Class 4**)
- Key switch, Area interlocks (depends on system), and remote firing or remote viewing (depends on system)
- Only individuals trained in the operation of the laser and laser safety may operate the laser system.
- Path of the laser light is well defined and controlled (curbs, beam traps/blocks, external shutters, curtains).
- Hazardous beams are terminated using beam stops.
- All light levels in excess of the MPE must be confined to the laser table if feasible - establish Nominal Hazard Zone (NHZ).

Eyewear Storage

- Proper storage reduces damage and extends eyewear lifetime
- Helps to keep eyewear from being misplaced
- Store similar eyewear together for ease of access

Interlock Systems

Interlock systems that are tied to the illuminated warning sign and possibly to the operation are sometimes required.

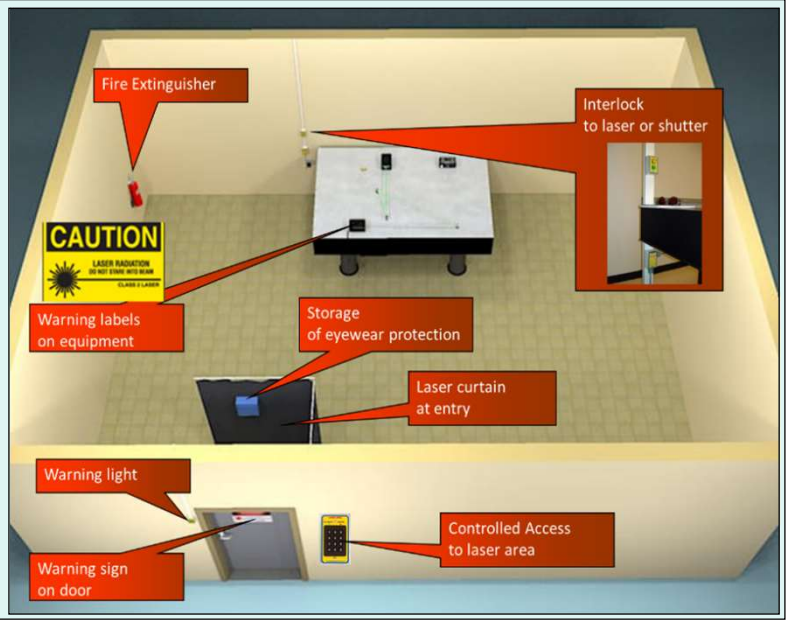
Access Control

Class 3B and Class 4 laser labs require access control.

- Self-closing device on door is a requirement for laser labs
- Standard keyed lock should not be used, too many people have "master keys"
- Key card or Cipher locks are preferred

Space is often limited in the lab, but efforts need to be taken to laser users sufficient walkway space around the lab and equipment.

- Minimum aisle clearance of 24" Main aisles used for emergency egress must have clearance of 36"
- Consider cable management



Controlling the Beam

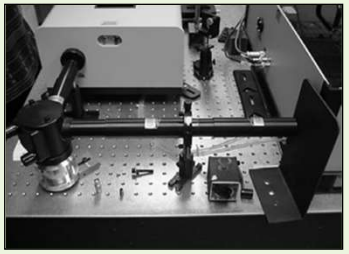
It is a best practice in laser safety to ***point the beam path away from doorways. Consider beam path in the design.*** Use barriers around the optical table.

External Shutters, Beam Traps, and Blocks



Table and Beam Curbs


Enclosures

9 Traits of a Positive Safety Culture

1. **Leadership Safety Values and Actions**
2. **Problem Identification**
3. **Personal Accountability**
4. **Work Processes**
5. **Continuous Learning**
6. **Environment for Raising Concerns**
7. **Effective Safety Communication**
8. **Respectful Work Environment**
9. **Questioning Attitude**

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Beam Alignment

- **Use the minimum beam power** / energy for as many alignment steps as possible or use a low-power coaxial laser beam for path simulation.
- **Wear protective eyewear at all times during the alignment**. Make sure that it is appropriate to the wavelength of the laser and power.
- **Isolate and demarcate the area** to avoid distractions and minimize the hazard to others.
- **Terminate the beam** at the end of its useful path.
- **Know where the beam is** going at all points

Invisible Beams and Alignment

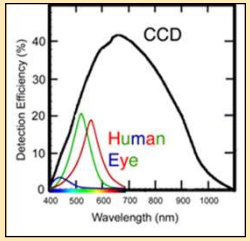
Infrared/UV imager: Always use with protective eyewear.


Alignment cards: Face down and away to prevent stray beams from the reflective coating. Note the power rating.





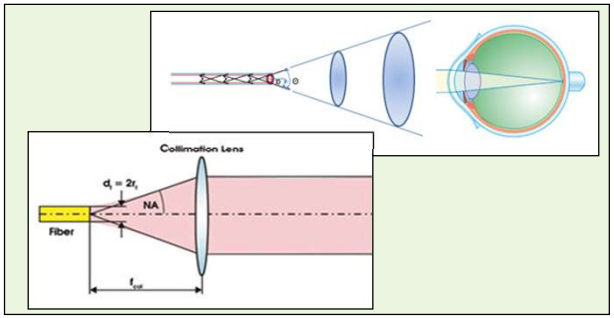
CCD cameras



Co-alignment lasers

Fibers

- Optical fibers and fiber lasers can carry kilowatts of laser power and moderate pulse energies at high average power.
- The light emitted from a fiber diverges quickly, but is easily re-collimated or focused
- Optical Fibers can be easily broken causing light to scatter randomly
- High power fiber lasers can also ignite flammable materials they come into contact with due to the spontaneous emission and scattered light emitted through the sides of the fiber.
- Shards of fiber are tiny and often very sharp. Being transparent they practically disappear once embedded in the skin. They can easily puncture the skin, burying themselves deep enough to be difficult to pull out.
- Always wear safety glasses with side shields for eye protection from fiber shards or splinters. Treat fiber optic splinters the same as treat glass splinters. Hands should be washed thoroughly before touching eyes or face.



Critical Radius