Laser Safety

Training Notes for URI Laser Users

Laser

The word *laser* is an acronym for Light Amplification by Stimulated Emission of Radiation.

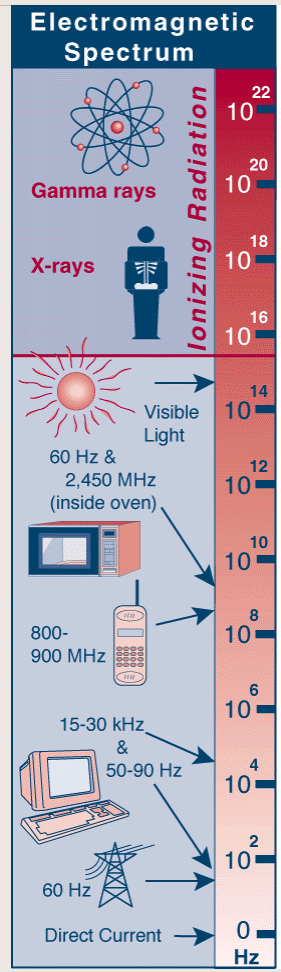
Laser symbol

Laser

For the purposes of this discussion, the word *laser* will be limited to electromagnetic radiation-emitting devices using light amplification by stimulated emission of radiation at wavelengths from 180 nanometers to 1 millimeter.

Electromagnetic Spectral Regions

- Ultraviolet (180 to 400 nanometers)
- Visible (400 to 700 nanometers)
- Infrared (700 nanometers to 1 millimeter)



Hazard

Laser radiation of sufficient intensity and exposure time can cause irreversible damage to your eyes and/or skin.

Laser Light

- Monochromatic
- Directional
- Coherent.

Monochromatic

All the light produced by the laser consists of a single wavelength.

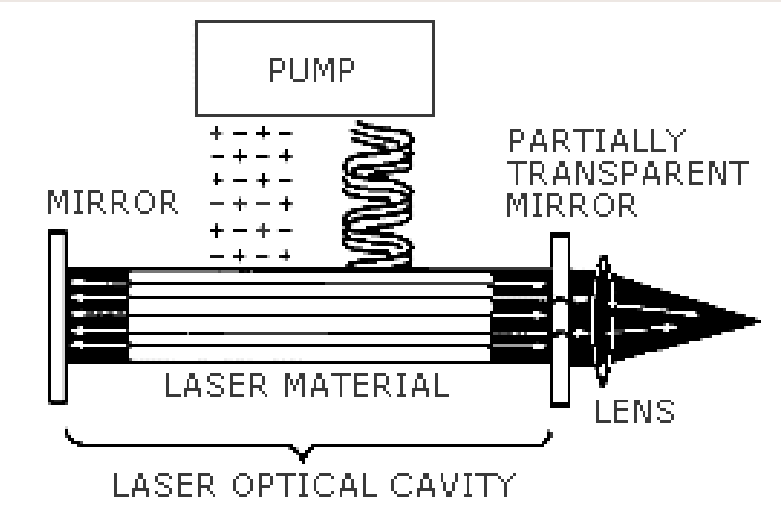
Directional

The beam of light produced by the laser has a very low divergence. Thus, it can maintain a high beam intensity over long ranges.

Coherent

The waves of light from a laser are in phase with each other.

Components of A Laser



Laser diagram courtesy of OSHA

- Laser Material
- Pump Source
- Mirror and Partially Transparent Mirror
- Lens

Laser Output

- Continuous Wave (steady output)
- Pulsed (short time duration pulses)

Q-Switched Lasers

A Q-switch is a mechanism to provide extremely short laser pulses (typically a few nanoseconds in duration).

The Q-switch may use a rotating prism, a pockets cell or a shutter device to create the pulse.

Laser Risks

- The most common risk is damage to the eyes.
- Other common laser concerns include skin damage, electrical hazards from high-energy power sources, chemical exposure, fire/explosion hazards, and exposure to cryogenic materials.
- Many lasers emit invisible ultraviolet or infrared radiation.

Damage Mechanisms

- Thermal damage
- Photochemical reactions
- Thermally-induced acoustic shock waves

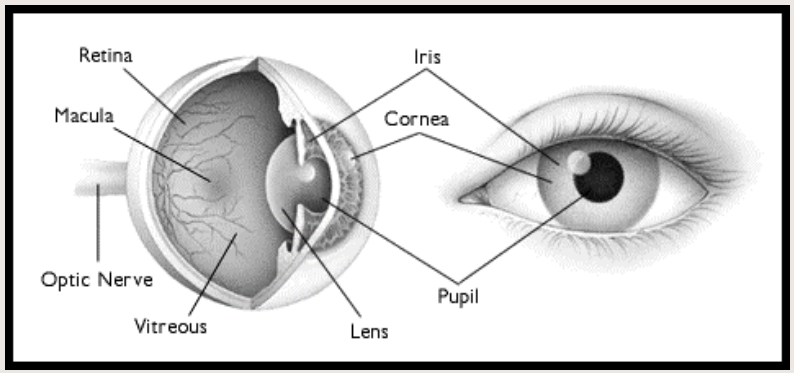
Thermal Damage

Tissue proteins are denatured due to temperature rise following absorption of laser energy ….most common mechanism

Thermal Effects Factors

- Absorption & scattering coefficients of the tissues at the laser wavelength
- Radiant exposure of the laser beam
- Duration of exposure & pulse repetition
- Local vascular flow
- Size of the area irradiated

Human Eye



The principal hazard associated with laser radiation is exposure to the eye.

A laser can produce retinal intensities orders of magnitude greater than conventional light sources, and, in fact brighter than the sun.

Laser Exposure Limits - Terms

- MPE (Maximum Permissible Exposure)
- NHZ (Nominal Hazard Zone)
- NOHD (Nominal Ocular Hazard Distance)

Laser Exposure Limits - Terms

- **MPE (Maximum Permissible Exposure)**
  The highest laser energy to which the eye or skin can be exposed for a given laser
- NHZ (Nominal Hazard Zone)
- NOHD (Nominal Ocular Hazard Distance)

3 Factors Determine the MPE

- The wavelength of the laser light
- The energy involved in the exposure
- The duration of the exposure

MPE Values

MPE values for eyes and skin are listed for various combinations of wavelength and exposure duration in **tables 5** and **7** of *ANSI Standard Z136.1*.

Laser Exposure Limits - Terms

- MPE (Maximum Permissible Exposure)
- **NHZ (Nominal Hazard Zone)**
  Area within which the MPE is equaled or exceeded
- NOHD (Nominal Ocular Hazard Distance)

Laser Exposure Limits - Terms

- MPE (Maximum Permissible Exposure)
- NHZ (Nominal Hazard Zone)
- **NOHD (Nominal Ocular Hazard Distance)**
  Distance along the axis of the direct laser beam to the human eye beyond which the MPE of the laser is not exceeded.

What do I need to know to work safely with a laser?

- Its classification
- Wavelength of its output
- Its power output
- Appropriate eyewear

Four Classes of Lasers:

Class 1: Lowest power lasers that do not emit hazardous levels

Class 2: Low-power lasers that pose a hazard only if viewed directly for extended periods

Class 3: Medium-power lasers that pose moderate risk and can cause injury

Class 4: High-energy, high-risk lasers that can cause injury to the eyes and skin from the direct beam or diffused reflection

Laser Hazard Controls

1. Engineering Controls
2. Personal Protective Equipment
3. Administrative and Procedural Controls
4. Special Controls

Some Basic Engineering Controls

- ✓ Use the minimum radiant energy or laser power level for the application
- ✓ Terminate the beam at the end of its useful path
- ✓ Enclose the beam path or locate the laser system below 1.2 meters or above 2 meters from the floor.
- ✓ Securely mount the laser system on a stable platform to maintain the beam in fixed location during operation and limit beam traverse during adjustments
- ✓ Confine primary beams and dangerous reflections to the optical table

Personal Protective Equipment

Eye Protection

- ✓ Always wear appropriate eye protection when lasers are in use
- ✓ Use laser protective eyewear approved by ANSI
- ✓ Inspect eyewear before each use for pitting and cracking of the attenuating material and for mechanical integrity and light leaks in the frame

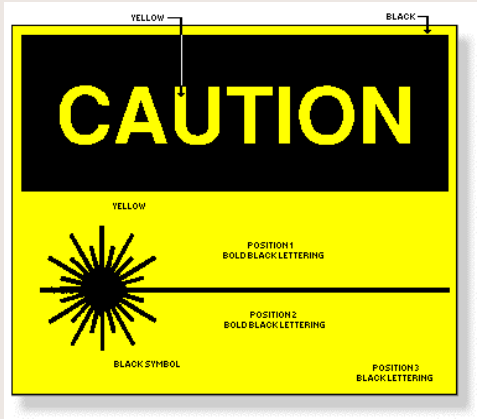
Skin Protection

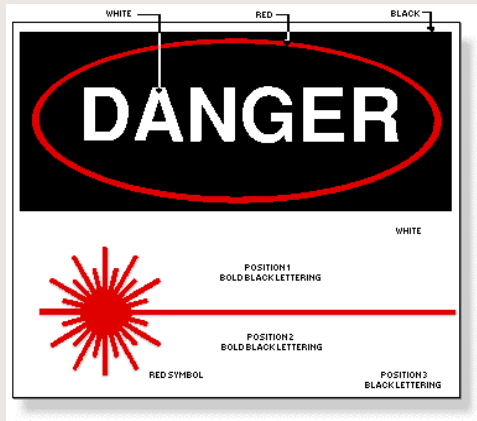
- ✓ Wear protective clothing opaque to the wavelength of the laser beam
- ✓ Protect bare skin with creams appropriate for the wavelength of the laser beam

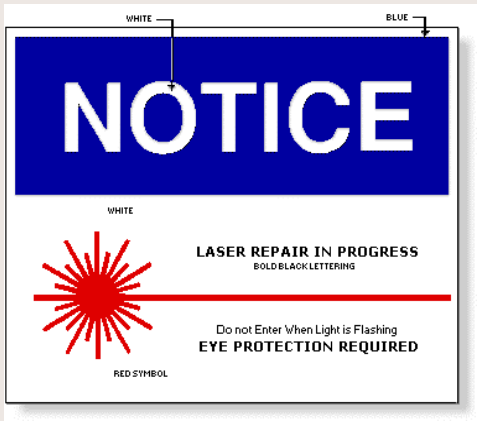
Some Basic Administrative & Procedural Controls

- ✓ Appropriately train all individuals assigned to service, maintain, install, adjust and operate laser equipment
- ✓ Provide baseline eye examinations before using the laser
- ✓ Post each entrance to the operating area with an appropriate warning sign
- ✓ Prepare and use standard operating procedures
- ✓ Maintain a log showing periods of use, service and maintenance
- ✓ Ensure that a laser classification label is conspicuously affixed to the laser housing

Warning Signs







Common Elements

1. Laser Symbol

2. Customized Wording

3. Laser's Classification

Special Controls

- ✓ Install a lighted warning sign activated when the laser is energized with a fail-safe interlock at the entrances to laboratories with a Class 3b or 4 laser
- ✓ Equip access doors to areas in which a Class 3b or Class 4 laser is being operated with a safety interlock
- ✓ Interlock all protective enclosures to prevent operation of the laser equipment without the enclosure
- ✓ Install visual or audible beam-warning devices in areas where personnel may be exposed to UV or IR (invisible beams) in excess of the MPE
- ✓ Survey laser areas with appropriate measuring devices to locate and identify direct and reflected beams that exceed MPE
- ✓ When working with power supplies, remove jewelry, stand on a dry surface, and work with only one hand at a time. Observe high voltage precautions