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Laser Safety Basics

Document Number: 127

"LASER" is an acronym for Light Amplification by Stimulated Emissions of Radiation

The laser was first developed in 1960 by Dr. Charles Maiman, a scientist working for Hughes Aircraft Company. Advances in laser technology have since allowed for the expanded use of lasers into many areas of industry, communications, research, the military and numerous medical applications. Eye safety is the number one concern for anyone working with or near a laser. As quick as it takes to blink, the laser can severely damage your eye. Though the injuries are rare, they are permanent. Engineering controls are the preferred method of protection but cannot be relied on as the only protection. Protective eyewear may also be necessary— especially during the alignment of a laser beam.

ENGINEERING CONTROLS

Engineering controls, such as protective housings, remote controls, or enclosed laser-beam paths, ensure protection for laser operators except when the operator needs to set up, adjust or maintain the beam. These technicians are most at risk for serious injury. The Laser Safety Officer (LSO) is responsible for monitoring and enforcing the control of laser hazards, which includes operation, maintenance and service.

1. Operation: Lasers and laser systems are classified on the basis of the level of the laser radiation accessible during intended use.
2. Maintenance: Tasks necessary to assure routine performance of the laser. These include frequently required tasks such as cleaning and replenishing of expendables. Maintenance usually does not require beam access.
3. Service: Performed with less frequency and usually requires laser beam access. Examples of service include replacing the laser resonant mirrors and repairing faulty components. Instructions for safe operation should be supplied by the manufacturer; the LSO must provide any additional safety instructions to employee safety.

EYE SAFETY

The eye is damaged because of the way it focuses, with the cornea and lens focusing the light beam on a small spot on the retina. Vision damage is usually severe, and may result in blindness, which is why direct viewing of the laser source and its reflections should be avoided. A laser's reflective beam intensity may approach its direct beam intensity; therefore, no reflective objects or surfaces should be in the area with the laser.

Light is radiant energy and is defined as electromagnetic radiation. It is measured in wavelengths and described in nanometers (nm). A laser produces an intense beam of light of a single wavelength (or color) and frequency. Laser intensity varies from low power (Class 1, 2, and 3A lasers), to medium (Class 3B) to high power (Class 4). The American National Standards Institute (ANSI) classifies lasers into categories and gives guidelines on laser safety in the standard Z136.1. Following are laser categories as outlined by ANSI.

Class 1: Cannot emit laser radiation at known hazard levels. Users of Class 1 lasers are generally exempt from radiation hazard controls during operation and maintenance, but not necessarily during service. Most Class 1 industrial lasers consist of a higher class laser enclosed in a properly interlocked and labeled protective enclosure.

Class 2: Low-power visible lasers. Emit laser radiation above Class 1 levels and radiant power not above 1mW. The human aversion reaction to bright light will protect the person from this low level. Example: a supermarket laser scanner.

Class 3A: Intermediate-power lasers. Only hazardous for intrabeam viewing. Some limited controls are usually recommended. Example: a helium-neon laser used in the construction industry.

Class 3B: Moderate-power lasers. Not generally a fire hazard and not capable of producing a hazardous diffuse reflection, except in instances of intentional staring at distances close to the diffuser. Specific controls are recommended.

Class 4: High-power lasers. Hazardous to view under any condition (directly or diffusely scattered). Potential fire hazard and a skin hazard. Significant controls are required for Class 4 laser facilities. Example: an Excimer laser operating in the ultraviolet.

A laser's eye-damaging ability varies depending on which area of the light spectrum it is generating. The ultraviolet radiation laser (180-400nm) causes corneal burns. Lasers in the near-infrared region (780-1800nm) cause retinal damage. These are usually Class 2, 3A, 3B and 4 lasers. The high-powered lasers, Class 3B and 4, can also cause electrical shock and skin burns. A skin cover, like opaque gloves and tightly woven fabrics, and or a "sun screen" may be recommended.

A laser consists of a resonant optical cavity filled with an active medium. The medium is acted upon by some source of excitation energy. The media could be one of three types: a solid state, a gaseous state, or a semiconductor or injection-type. Solid lasers use a crystal (i.e. ruby), glass or a semiconductor (argon) as the light amplifying substance, producing a pulsating laser beam. A gaseous state laser (helium-neon) produces a continuous beam.

For information on the laser's wattage or power of the laser, refer to the instruction/maintenance manual.

PROTECTIVE EYEWEAR

How does laser eyewear protect your eyes? The lens of the eyewear is a filter/absorber designed to reduce light transmittance of a specific wavelength. The lens can filter out (or absorb) a specific wavelength while maintaining adequate light transmission for other wavelengths. The absorption capability of the filtering media is called the optical density (OD). The OD is always expressed as a factor of 10. An OD of 5 means the filter has reduced the power of the beam to 1/100,000 of its original power. The required OD is the minimum OD necessary to reduce the beam to a non-hazardous level. The OD of the eyewear has to be at least equal to or greater than the required OD.

When choosing appropriate eyewear, time is also a consideration. How long will the eyewear protect your eye before the beam goes through? How long will you have to react if you are hit with a direct beam? According to the ANSI standard, protective eyewear shall exhibit a damage threshold for a specified exposure time (typically 10 seconds). The eyewear shall be used in a manner so that the damage threshold is not exceeded in the worst case exposure situation.

Main points to determine the type of eyewear required for a specific laser include:

- Laser type (Helium-Neon, CO2, YAG, etc.)
- Wavelength in nanometers (nm)
- Mode of operation - continuous wave versus pulse wave
- Power in watts for continuous wave laser
- Power in joules for pulse wave laser
- Pulse length in seconds for pulse wave laser
- Pulse frequency in hertz for pulse wave laser
- Lens material desired
- Frame style desired

From time to time, requests are received for laser eyewear that Lab Safety Supply may not offer as standard items. To facilitate a timely and accurate response to those requests, a Laser Eyewear Questionnaire has been developed (see EZ Facts® Document 287).

NON-BEAM HAZARDS

Once protective eyewear is selected, other safety issues—called non-beam hazards—need consideration.

1. A potential explosion hazard may occur from the buildup of high pressures of gases in the flash lamp when it is fired.
2. Sometimes cryogenic gases (liquid nitrogen or liquid helium) are used to cool the crystal (ruby, neodymium, etc.). Skin burns can result from contact with these gases.
3. If these cryogenic gases leak into a closed room, they are capable of replacing the oxygen in the air, thus creating an oxygen-deficient atmosphere.
4. Many industrial uses involve a laser cutting plastics, metals or wood products. When the object is heated by the laser beam, hazardous vapors or fumes could be given off. These are called Laser-Generated Air Contaminants (LGAC).
5. Electrical shock or electrocution may occur from contact with exposed utility power. Exposures can occur during setup, installation, maintenance and service of the laser. The protective covers are often removed to allow access to the components.
6. Fire is a potential hazard with Class 4 laser systems. The use of flame-retardant materials should be encouraged.