Toolbox Talks

Laser Safety Part 1

LASER is an acronym which stands for Light Amplification by Stimulated Emission of Radiation. The laser produces an intense, highly directional beam of light. The most common cause of laser-induced tissue damage is thermal in nature, where the tissue proteins are denatured due to the temperature rise following absorption of laser energy. OSHA.gov

"DANGER - *Laser in Use"* is a common poster in the industry today. It has become common because devices that use laser light have so many practical uses. They guide blade alignments on portable cut-off saws & set-up large rip saws in a timber mill; in construction, they are used in surveying equipment & assist with the layout of ceiling grids or interior walls. Lasers can be used for many operations that require laying a perfectly straight line over a long &/or uneven surface. Higher power devices can cut through steel with precision results. **All-in-all, lasers are a valuable tool for improving productivity & accuracy. Yet, because they are so common in the industry today, they are sometimes taken for granted. Lasers should always be treated with respect. They represent dangers to those who work with them & those who work *around* them.** Lasers are generally divided into four basic classifications. These classifications are based upon a system of graded risk. The higher the class, the greater potential for personal injury -- particularly to the eyes or skin.
(See reverse for laser classifications)

→**Some of the basic safety precautions for lasers are:**

- Every laser operator must be trained & qualified. Operators must have proof of this qualification & it must stay with them at all times.
- All work areas where lasers are used must be posted with standard laser warning placards.
- A laser must *never* be intentionally directed at another employee.
- The laser must be turned off, capped, or its beam shuttered when left unattended for a substantial period of time, such as at meal times, overnight, or during a work shift change.
- Lasers must not be used when it is raining, snowing, foggy, or there is heavy dust in the air. Such conditions may deflect or scatter the radiation. If production cannot be postponed, then employees must be kept well out of range of the source & target of the laser.

The intensity of laser light can be harmful. The next time you find yourself working near a laser or laser-guided equipment, check the classification. What are the precautions? What PPE is required? Do posted signs warn of the lasers use? Respect the CAUTION or DANGER signs - They are there to keep you out of harm's way.

The two major concerns in safe laser operation are exposure to the beam & the electrical hazards associated with high voltages within the laser & its power supply. While there are no known cases of a laser beam contributing to a person's death, there have been several instances of deaths attributable to contact with high voltage laser-related components. Beams of sufficiently high power can burn the skin or, in some cases, create a hazard by burning or damaging other materials, but the primary concern with regard to the laser beam is potential damage to the eyes, which are the part of the body most sensitive to light.

A number of government agencies & other organizations have developed standards for laser safety, some of which are legally enforceable, while others are simply recommendations for voluntary compliance. The majority of legally required standards pertain to manufacturers of laser equipment, although the end user of the laser has the largest interest in safe operation - the prevention of personal debilitating injury or even death.

Damage to the eye can occur instantaneously, & precautions must be taken in advance to minimize the risk since avoidance at the last moment is not a possibility. Laser emission is similar to direct sunlight exposure in that the light arrives at the eye in parallel rays, which are very efficiently focused on the retina, the rear surface of the eye that senses light.

Anatomy of the Human Eye

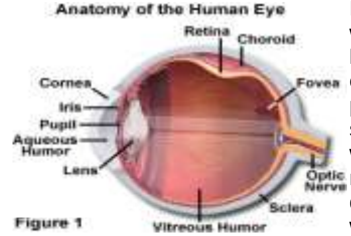

Figure 1

General anatomy of the human eye, with emphasis on the structures that are likely to be damaged by absorption of intense radiation.

Potential hazards to the eye depend on laser light wavelength, beam intensity, distance from the laser, & power of the laser (both average power over long intervals & peak power produced in a pulse). The wavelength of the laser radiation is significant because only light within the wavelength range of approximately 400 to 1400 nanometers can penetrate the eye sufficiently to damage the retina. Near-ultraviolet light of certain wavelengths can damage layers of the eye near the surface, & can contribute to cataract formation in the lens, especially in younger persons, whose eye tissues have greater transparency in this wavelength range. Light in the near-infrared can produce surface damage as well, although at a higher damage threshold than for ultraviolet light.

Of the many laser safety standards developed by both governmental & other agencies, the one most often relied upon in the United States is the American National Standards Institute's Z136 series. **The ANSI Z136 laser safety standards are the basis for the Occupational Safety & Health Administration (OSHA) technical rules used to evaluate laser hazard issues & are also the reference for many states' occupational safety rules pertaining to laser use.** All laser products sold in the USA since 1976 are required to be certified by the manufacturer as meeting specified product safety standards for their designated classification, & they must be labeled as to their class. Research results combined with an accumulated understanding of the hazards of sunlight & other light sources have led to the establishment of estimated nominal safe exposure limits for most types of laser radiation. A system of laser hazard categories, based on the known maximum permissible exposures & experience gained from years of laser use, has been developed to simplify the application of safety procedures to minimize or prevent accidents. **The laser manufacturer is required to certify that a laser product falls into one of the categories, or risk classes. & to label it accordingly.**

Laser Hazard Warning Signs

Figure 4

Toolbox Talks

Laser Safety Part 2

Classification of Lasers:

→**Class I** lasers are considered safe under any exposure condition inherent in the design of the product. The low powered devices (0.4 mw at visible wavelengths) that use lasers of this category include laser printers, CD players, & survey equipment, & they are not permitted to emit levels of optical radiation above the exposure limits for the eye. A more hazardous laser may be incorporated within the enclosure of a Class I product, but no harmful radiation is permitted to escape during use or maintenance (this does not necessarily apply during service). No safety requirements are specified for the use of this class of laser.

→**Class IA** is a special designation for lasers that are not intended for viewing, such as supermarket laser scanners. A higher power is permitted than for Class I lasers (not more than 4 mw), but the Class I limit must not be exceeded for an emission duration in excess of 1000 seconds.

→**Class II** are low-power lasers that must emit a visible beam. The brightness of the beam is relied upon to prevent staring into the beam for long enough periods to cause eye damage. These lasers are limited to a radiant power less than 1 mw, which is below the maximum permissible exposure for momentary exposure of 0.25 second or less. The natural aversion reaction to visible light of this brightness is expected to protect the eyes from damage, but any intentional viewing for extended periods could result in damage. Some examples of this class of laser are demonstration lasers for classroom use, laser pointers, & range-finding devices.

→**Class IIIA** lasers are continuous wave intermediate power (1-5 mw) devices, with similar applications as Class II, including laser scanners & pointers. They are considered safe for momentary viewing (less than 0.25 second), but should not be viewed directly or with any kind of magnifying optics.

→**Class IIIB** lasers are of medium power (continuous wave 5-500 mw, 10 joules/cm^2 in pulsed devices) & are not safe for direct viewing or viewing of specular reflections. Specific safety measures are recommended in the standards for control of hazards with this laser class. Examples of applications of this laser type are spectroscopy, confocal microscopy, & entertainment light shows.

→**Class IV** lasers emit high power, in excess of the limit for Class IIIB devices, & require stringent controls to eliminate hazards in their use. Both the direct beam & diffuse reflections from these lasers are damaging to the eyes & skin & are potential fire hazards depending upon the materials that they strike. Most laser eye injuries involve reflections of Class IV laser light; consequently, all reflective surfaces must be kept away from the beam & appropriate eye protection worn at all times when working with these lasers. Lasers of this category are employed for surgery, cutting, drilling, micromachining, & welding.

→**Electrical Hazards:** The hazards associated with electrical components & the supply of power to lasers are essentially the same for nearly all types, & safety precautions specific to each laser categories are not necessary. Of the primary functional laser categories: gas, solid state, dye, & semiconductor, all except semiconductor lasers require high voltages, & often high current, to produce a beam. A particularly hazardous condition is created in lasers that may retain high voltages in capacitors or other components long after the laser is switched off. This situation is especially common in pulsed lasers & should always be kept in mind when instrument covers are removed for any purpose. **The safest approach is to always assume that a shock hazard exists until otherwise determined.** Many lasers utilize high voltages until laser emission is established & then operate at electrical levels similar to conventional household line voltages; this should not be taken as a justification for lack of precautions appropriate for any electrical device.

→**Eye Hazards:** It is notable that a common warning for most categories of laser is to avoid viewing the beam with any magnifying optical device. **A primary danger to the human eye posed by lasers results from the fact that the eye itself is a highly precise & efficient focusing optical device for light within a certain wavelength range.** The potential for laser emission causing injury to the different structures of the eye depends upon which structure absorbs the beam energy. The absorption characteristics of the different eye tissues & the wavelength & intensity of the laser light determine whether damage occurs to the cornea, lens, or retina. Direct viewing of a point source of light produces a very small focal spot on the retina, resulting in a greatly increased power density & a high probability of damage. The dangers are similar in certain respects to those presented by direct viewing of the sun, although the potential intensity is even higher for lasers. Because of the high degree of focusing that occurs within the eye, exposure to a relatively weak laser beam can cause permanent, instantaneous damage. Consequently, when a powerful laser is being utilized, a specular reflection of even a few percent, for a fraction of a second, is capable of inflicting eye damage. In contrast, when the laser beam is scattered by reflection from a rough surface, or even from dust in the air, the diffuse reflection enters the eye at a larger angle, producing a large image on the retina; diffusion of the beam in this fashion reduces the likelihood of eye damage.

→**Skin Hazards:** Because the skin is the largest organ of the body, it is at the greatest risk of exposure to a laser beam, & effectively protects most of the other organs from exposure (with the exception of the eyes). It is important to consider that many lasers are designed for the purpose of material alteration, such as cutting or drilling of materials that are much more resistant than skin. **The arms, hands, & head are the portions of the body most likely to be inadvertently exposed to the laser beam when alignment or other experimental manipulations are being performed; if the beam has sufficient intensity, thermal burns, photochemical damage, & acoustic lesions may occur.** The greatest hazard to the skin results from the high power density of a laser beam, & the wavelength of the radiation determines to some extent the depth of skin damage & the type of injury that results. If lasers having the potential of causing skin damage are being used, adequate precautions should be taken to protect the skin, such as wearing long sleeves & gloves made of appropriate fire-resistant material.

→**Additional Non-Beam Hazards:** In many industrial applications, lasers are used to perform cutting & welding operations; the heating involved can result in emission of hazardous fumes or vapors, which must be safely removed from the working environment. In flash lamp-pumped systems, a potential explosion hazard exists from the buildup of high pressures within the flash tube. The instrument housing should be designed & maintained to contain fragments of the lamp if this type of explosive failure occurs. Cryogenic gases, such as liquid nitrogen or liquid helium, may be used to cool the laser & exposed skin is subject to burn injuries if contacted by the cold liquids. **The electrical hazards associated with laser equipment have been discussed, but cannot be overemphasized, due to common removal of instrument covers during laser installation, alignment, servicing, & maintenance.** Some laser systems (Class IV or 4, in particular) pose a potential fire hazard if the beam contacts flammable substances; flame-retardant materials should be utilized wherever beam exposure is possible.