

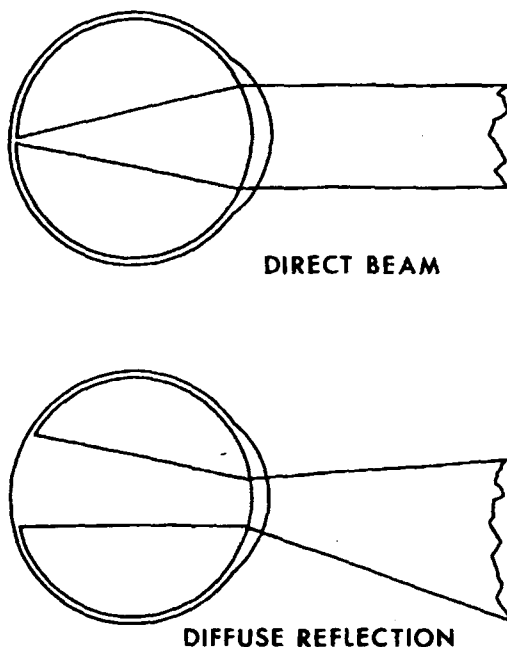


FIG 44-26 - Observing laser light. Above: Parallel rays of a laser may be focused to a point image by the eye. Below: Rays from an extended source (as from a conventional lamp, or rays from a diffuse reflection of a laser beam) produce a sizeable (and less dangerous) image at the retina.

tion of a laser beam) produce a sizeable image at the retina. Light from a laser entering the eye is concentrated 100,000 times at the retina. Because of this focusing effect, the eye is by far the organ of the body most subject to damage. Hence, injury to the skin is seldom of concern except in dealing with very high-powered lasers.

Exposure criteria. A number of groups* and others have developed recommended safe ocular exposure levels for laser radiation (subsequently referred to as safe levels).

Since the threshold doses presented in most biologic research literature are generally presented in terms of retinal intensities, early standards proposed safe levels at the retina. Such levels created serious problems for many users who were not familiar enough with physiological optics to extrapolate retinal doses to the exterior (cornea) of the eye. Safety factors ranging from two to 100 have

been utilized by different groups in arriving at safe levels from the same biologic data. Opinion varies as to whether safety levels should be based upon cell damage detected by biomicroscopic methods, by clearly evident damage to the retina determined ophthalmoscopically, or by detectable functional loss of vision. It may well be that there exists a significant difference between acute and chronic effects of laser exposure. In general, it has been the practice on the part of those who have proposed safe levels to be conservative. Except where lasers are utilized in an outdoor environment over long ranges, conservative levels have not resulted in significant operational restrictions.

Safe levels which have been utilized by the U.S. Army Environmental Hygiene Agency are (joules per square centimeter—a unit for predicting damage potential of a laser beam) 10^{-7} J/sq cm for q-switched and 10^{-6} J/sq cm for non-q-switched pulsed lasers based upon a wavelength of 694.3 mμ, and 10^{-6} W/sq cm for continuous-wave lasers, based upon white light. Additional safety factors of from two to ten are utilized with these levels, depending upon the situation.

Reflections. The foregoing exposure criteria assume that the incident laser radiation consists of a parallel beam and that the eye is focused at infinity. This would be true for intra-beam viewing within the direct beam or for a specularly reflected beam, however, most reflections which individuals view are diffuse in nature. A safe retinal irradiance

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