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single color or wavelength and frequency, in contrast to conventional light sources, which produce random, disordered light wave mixtures of various frequencies. The laser (Light Amplification by Stimulated Emission of Radiation) is made up of light waves that are nearly parallel to each other, all traveling in the same direction. Light-emitting atoms are "pumped" full of energy and stimulated to fall to a lower energy level, giving off light waves that are directed to produce the coherent laser beam.

The maser, the laser's predecessor, emits microwaves instead of light. Some companies call their lasers "optical masers." Proposed uses for the laser include machining and cutting of metals, welding of microscopic parts, and systems for high-capacity communications.

Since the laser is highly collimated (has a small divergence angle), it can have a large energy density in a narrow beam. Direct viewing of the laser should therefore be avoided. The work area should contain no reflective surfaces (such as mirrors or highly polished furniture) for even a reflected laser beam can be hazardous. Suitable shielding to contain the laser beam should be provided.

Potential laser hazards. The hazards associated with laser operations fall into two categories—those from the laser itself and those from associated equipment.

The solid-state lasers present the greatest hazards, because of their high achievable peak powers. Gas and injection lasers, although not as powerful as the solid-state lasers, are capable of producing power outputs that can cause permanent eye damage and skin burns if proper safety practices and procedures are not followed. Injection lasers, however, at this time exhibit low power outputs compared to the solid-state and gas lasers.

The primary hazard associated with laser operations is the laser beam. This beam is capable of inflicting serious injury to personnel, in particular to the unprotected eye.

Experience has shown that specular reflections may approach direct beam intensities. These reflections are difficult to predict and can make off-axis viewing just as dangerous as on-axis viewing.

Most laser energy pump sources require

the use of high voltages and should be treated with caution. This component of the laser system can produce serious electric shock and burns.

Ozone may be produced as a result of electrical discharges or ionization of the air surrounding high power laser beams.

Any high voltage equipment (>15,000 volts) is capable of generating X rays. However, presently the majority of lasers used in industrial operations operate within the range of 1 to 4 kv.

The xenon flash lamp used in solid-state lasers produces brilliant white light flashes. This light is capable of producing ultraviolet and infrared radiation. Another danger is the build-up of high pressures of the gases in the flash lamp when it is fired, thus leading to a potential explosion.

Associated equipment. Cryogenic gases such as liquid nitrogen and liquid helium are sometimes used to cool the crystal (ruby, neodymium, etc.) in solid-state lasers. These liquid gases are capable of producing skin burns upon contact. If these gases leak into a closed room, they are capable of replacing oxygen in the atmosphere. This latter condition can produce an oxygen-deficient atmosphere. Flammable solvents and materials may be associated with a particular laser operation and are capable of being ignited by a laser beam.

Biological effects. The eye is the organ most vulnerable to injury induced by laser energy. The reason for this is the ability of the cornea and lens to focus the parallel laser beam on a small spot on the retina.

The fact that infrared radiation of certain lasers may not be visible to the naked eye contributes to the potential hazard.

Lasers generating in the ultraviolet range of the electromagnetic spectrum produce corneal burns rather than retinal damage, because of the way the eye handles ultraviolet light.

Other factors which have a bearing on the degree of eye injury induced by laser light are (a) the pupil size—the smaller the pupil diameter, the less the amount of laser energy permitted to the retina, (b) the power of the cornea and lens to focus the incident light on