

## Glossary of Laser Terms

**Absorb** To transform radiant energy into a different form, with a resultant rise in temperature.

**Absorption** Transformation of radiant energy to a different form of energy by the interaction with matter, depending on temperature and wavelength.

**Accessible Emission Level** The magnitude of accessible laser (or collateral) radiation of a specific wavelength or emission duration at a particular point as measured by appropriate methods and devices. Also means radiation to which human access is possible in accordance with the definitions of the laser's hazard classification.

**Accessible Emission Limit (AEL)** The maximum accessible emission level permitted within a particular class. In ANSI Z 136.1, AEL is determined as the product of accessible emission Maximum Permissible Exposure limit (MPE) and the area of the limiting aperture (7 mm for visible and near-infrared lasers).

**Aperture** An opening through which radiation can pass.

**Argon** A gas used as a laser medium. It emits blue-green light primarily at 448 and 515 nm.

**Attenuation** The decrease in energy (or power) as a beam passes through an absorbing or scattering medium.

**Aversion Response** Movement of the eyelid or the head to avoid an exposure to a noxious stimulant, bright light. It can occur within 0.25 seconds, and it includes the blink reflex time.

**Beam** A collection of rays that may be parallel, convergent, or divergent.

**Beam Diameter** The distance between diametrically opposed points in the cross section of a circular beam where the intensity is reduced by a factor of  $e^{-1}$  (0.368) of the peak level (for safety standards). The value is normally chosen at  $e^{-2}$  (0.135) of the peak level for manufacturing specifications.

**Beam Divergence** Angle of beam spread measured in radians or milliradians (1 milliradian = 3.4 minutes of arc). For small angles where the cord is approximately equal to the arc, the beam divergence can be closely approximated by the ratio of the cord length (beam diameter) divided by the distance (range) from the laser aperture.

**Blink Reflex** See aversion response.

**Brightness** The visual sensation of the luminous intensity of a light source. The brightness of a laser beam is most closely associated with the radio-metric concept of radiance.

**Carcinogen** An agent potentially capable of causing cancer.

**Carbon Dioxide** Molecule used as a laser medium. Emits far infrared energy at 10,600 nm (10.6  $\mu\text{m}$ ).

**Closed Installation** Any location where lasers are used which will be closed to unprotected personnel during laser operation.

**CO<sub>2</sub> Laser** A widely used laser in which the primary lasing medium is carbon dioxide gas. The output wavelength is 10.6  $\mu\text{m}$  (10600 nm) in the far infrared spectrum. It can be operated in either CW or pulsed.

**Cornea** The transparent outer coat of the human eye, covering the iris and the crystalline lens. The cornea is the main refracting element of the eye.

**Coherence** A term describing light as waves which are in phase in both time and space. Monochromaticity and low divergence are two properties of coherent light.

**Collimated Light** Light rays that are parallel. Collimated light is emitted by many lasers. Diverging light may be collimated by a lens or other device.

**Collimation** Ability of the laser beam to not spread significantly (low divergence) with distance.

**Continuous Mode** The duration of laser exposure is controlled by the user (by foot or hand switch).

**Continuous Wave (CW)** Constant, steady-state delivery of laser power.

**Controlled Area** Any locale where the activity of those within are subject to control and supervision for the purpose of laser radiation hazard protection.

**Diffuse Reflection** Takes place when different parts of a beam incident on a surface are reflected over a wide range of angles in accordance with Lambert's Law. The intensity will fall off as the inverse of the square of the distance away from the surface and also obey a Cosine Law of reflection.

**Divergence** The increase in the diameter of the laser beam with distance from the exit aperture. The value gives the full angle at the point where the laser radiant exposure or irradiance is  $e^{-1}$  or  $e^{-2}$  of the maximum value, depending upon which criteria is used.

**Embedded Laser** A laser with an assigned class number higher than the inherent capability of the laser system in which it is incorporated, where the system's lower classification is appropriate to the engineering features limiting accessible emission.

**Emission** Act of giving off radiant energy by an atom or molecule.

**Enclosed Laser Device** Any laser or laser system located within an enclosure which does not permit hazardous optical radiation emission from the enclosure. The laser inside is termed an "embedded laser."

**Energy (Q)** The capacity for doing work. Energy is commonly used to express the output from pulsed lasers and it is generally measured in Joules (J). The product of power (watts) and duration (seconds). One watt second = one Joule.

**Erythema** The medical term for redness of the skin due to congestion of the capillaries.

**Excimer** An abbreviation for *excited dimer*. A gas mixture used as the active medium in a family of lasers emitting ultraviolet light.

**Exposure Duration** The total amount of time the ocular structures or skin are exposed to the laser beam.

**Fail-safe Interlock** An interlock where the failure of a single mechanical or electrical component of the interlock will cause the system to go into, or remain in, a safe mode.

**Gas Discharge Laser** A laser containing a gaseous lasing medium in a glass tube in which a constant flow of gas replenishes the molecules depleted by the electricity or chemicals used for excitation.

**Gas Laser** A type of laser in which the laser action takes place in a gas medium.

**Helium-Neon (HeNe) Laser** A laser in which the active medium is a mixture of helium and neon. Its wavelength is usually in the visible range. Used widely for alignment, recording, printing, and measuring.

**Infrared Radiation (IR)** Invisible electromagnetic radiation with wavelengths which lie within the range of 0.70 to 1000  $\mu\text{m}$ . These wavelengths are often broken up into regions: IR-A (0.7-1.4  $\mu\text{m}$ ), IR-B (1.4-3.0  $\mu\text{m}$ ) and IR-C (3.0-1000  $\mu\text{m}$ ).

**Iris** The annular pigmented structure that lies behind the cornea of the human eye. The iris forms the pupil.

**Intrabeam Viewing** The viewing condition whereby the eye is exposed to all or part of a direct laser beam or a specular reflection.

**Irradiance (E)** Radiant flux (radiant power) per unit area incident upon a given surface. Units: Watts per square centimeter. (Sometimes referred to as power density, although not exactly correct).

**Joule (J)** is a unit of energy (1 joule = 1 Watt-second).

**Laser** An acronym for light amplification by stimulated emission of radiation. A laser is a cavity with mirrors at the ends, filled with material such as crystal, glass, liquid, gas or dye. It produces an intense beam of light with the unique properties of coherency, collimation, and monochromaticity.

**Laser Accessories** The hardware and options available for lasers, such as secondary gases, Brewster windows, Q-switches and electronic shutters.

**Laser Controlled Area** See Controlled Area.

**Laser Device** Either a laser or a laser system.

**Laser Medium (Active Medium)** Material used to emit the laser light and for which the laser is named.

**Laser Rod** A solid-state, rod-shaped lasing medium in which ion excitation is caused by a source of intense light, such as a flash lamp. Various materials are used for the rod, the earliest of which was synthetic ruby crystal.

**Laser Safety Manager (LSM)** One who has authority to monitor and enforce measures to control laser hazards and effect the knowledgeable evaluation and control of laser hazards.

**Laser System** An assembly of electrical, mechanical and optical components which includes a laser. Under the Federal Standard, a laser in combination with its power supply (energy source).

**Lens** A curved piece of optically transparent material which, depending on its shape, is used to either converge or diverge light.

**Light** (see Visible Radiation)

**Limiting Aperture** The maximum circular area over which radiance and radiant exposure can be averaged when determining safety hazards.

**Macula** The small, uniquely pigmented and specialized area of the retina.

**Maintenance** Performance of those adjustments or procedures specified in user information provided by the manufacturer with the laser or laser system, which are to be

performed by the user to ensure the intended performance of the product. It does not include operation or service as defined in this glossary.

**Maximum Permissible Exposure (MPE)** The level of laser radiation to which a person may be exposed without hazardous effect or adverse biological changes in the eye or skin.

**Nd:Glass Laser** A solid-state laser of neodymium:glass offering high power in short pulses. A Nd-doped glass rod used as a laser medium to produce 1064 nm light.

**Nd:YAG Laser** Neodymium:Yttrium Aluminum Garnet. A synthetic crystal used as a laser medium to produce 1064 nm light.

**Neodymium (Nd)** The rare earth element that is the active element in Nd:YAG lasers and Nd:Glass lasers.

**Nominal Hazard Zone (NHZ)** The nominal hazard zone describes the space within which the level of the direct, reflected, or scattered radiation during normal operation exceeds the applicable MPE. Exposure levels beyond the boundary of the NHZ are below the appropriate MPE level.

**Ocular Fundus** The back of the eye. The ocular fundus may be seen through the pupil by use of an ophthalmoscope.

**Optical Cavity (Resonator)** Space between the laser mirrors where lasing action occurs.

**Optical Density** A logarithmic expression for the attenuation produced by an attenuating medium, such as an eye protection filter.

**Optical Fiber** A filament of quartz or other optical material capable of transmitting light along its length by multiple internal reflection and emitting it at the end.

**Optical Pumping** The excitation of the lasing medium by the application of light rather than electrical discharge.

**Optical Radiation** Ultraviolet, visible, and infrared radiation (0.35-1.4  $\mu\text{m}$ ) that falls in the region of transmittance of the human eye.

**Output Power** The energy per second measured in watts emitted from the laser in the form of coherent light.

**Plasma Radiation** Black-body radiation generated by luminescence of matter in a laser-generated plume.

**Power** The rate of energy delivery expressed in watts (Joules per second). Thus: 1 Watt = 1 Joule / 1 Sec.

**Protective Housing** A device designed to prevent access to radiant power or energy.

**Pulse** A discontinuous burst of laser, light or energy, as opposed to a continuous beam. A true pulse achieves higher peak powers than that attainable in a CW output.

**Pulse Duration** The "on" time of a pulsed laser, it may be measured in terms of milliseconds, microseconds, nanoseconds, picoseconds, and femtoseconds as defined by half-peak-power points on the leading and trailing edges of the pulse.

**Pulse Repetition Frequency (PRF)** The number of pulses occurring per second, expressed in hertz.

**Pulsed Laser** Laser which delivers energy in the form of a single or train of pulses.

**Pump** To excite the lasing medium. See Optical Pumping or Pumping.

**Pumped Medium** Energized laser medium.

**Pumping** Addition of energy (thermal, electrical, or optical) into the atomic population of the laser medium, necessary to produce a state of population inversion.

**Q-switch** A device that produces very short (~ 10-250 ns), intense laser pulses by enhancing the storage and dumping of electronic energy in and out of the lasing medium.

**Radiant Energy (Q)** Energy in the form of electromagnetic waves usually expressed in units of Joules (watt-seconds).

**Radiant Exposure (H)** The total energy per unit area incident upon a given surface. It is used to express exposure to pulsed laser radiation in units of  $J/cm^2$ .

**Reflection** The return of radiant energy (incident light) by a surface, with no change in wavelength.

**Refraction** The change of direction of propagation of any wave, such as an electromagnetic wave, when it passes from one medium to another in which the wave velocity is different. The bending of incident rays as they pass from one medium to another (e.g., air to glass).

**Resonator** The mirrors (or reflectors) making up the laser cavity including the laser rod or tube. The mirrors reflect light back and forth to build up amplification.

**Retina** The sensory tissue that receives the incident image formed by the cornea and lens of the human eye. The retina lines the posterior eye.

**Ruby** The first laser type; a crystal of sapphire (aluminum oxide) containing trace amounts of chromium oxide.

**Scanning Laser** A laser having a time-varying direction, origin, or pattern of propagation with respect to a stationary frame of reference.

**Secured Enclosure** An enclosure to which casual access is impeded by an appropriate means (e.g. door secured by lock, magnetically or electrically operated latch, or by screws).

**Semiconductor Laser** A type of laser which produces its output from semiconductor materials such as gallium arsenide (GaAs).

**Service** Performance of adjustments, repair or procedures on a non-routine basis, required to return the equipment to its intended state.

**Solid Angle** The ratio of the area on the surface of a sphere to the square of the radius of that sphere. It is expressed in steradians (sr).

**Source** The term source means either laser or laser-illuminated reflecting surface, i.e., source of light.

**Spectator** An individual who wishes to observe or watch a laser or laser system in operation and who may lack the appropriate laser safety training.

**Specular Reflection** A mirror-like reflection.

**Tunable Laser** A laser system that can be "tuned" to emit laser light over a continuous range of wavelengths or frequencies.

**Tunable Dye Laser** A laser whose active medium is a liquid dye pumped by another laser or flash lamps to produce various colors of light. The color of light may be tuned by adjusting optical tuning elements and/or changing the dye used.

**Ultraviolet (UV) Radiation** Electromagnetic radiation with wavelengths between soft X-rays and visible violet light, often broken down into UV-A (315-400 nm), UV-B (280-315 nm), and UV-C (100-280 nm).

**Viewing Portal** is an opening in an experimental system, allowing the user to observe the experimental chamber. All viewing portals and display screens included as an integral part of a laser system must incorporate a suitable means to maintain the laser radiation at the viewing position at or below the applicable MPE (eye safe) for all conditions of operation and maintenance. It is essential that the material used for viewing portals and display screens not support combustion or release toxic vapors following exposure to laser radiation.

**Visible Radiation (light)** Electromagnetic radiation which can be detected by the human eye. It is commonly used to describe wavelengths in the range between 400 nm and 700-780 nm.

**Watt (W)** The unit of power or radiant flux (1 watt = 1 joule per second).

**Wavelength** The distance between concentric oscillations of the light wave, usually measured from crest to crest, which determines its color. Common units of measurement are the micrometer (micron), the nanometer, and (earlier) the Angstrom unit.

**YAG** Yttrium Aluminum Garnet, a widely used solid-state crystal composed of yttrium and aluminum oxides and a small amount of the rare earth neodymium.