# Laser Glossary

**Accessible Emission Limit (AEL)**

The maximum output power or energy (or in the case of pulsed visible and near infrared Class 3 lasers) radiant exposure permissible for a given class. See paragraph d in Section 3, "General Laser Hazard Evaluation."

**Accessible radiation**

Any radiation to which the person's eye or skin can be exposed during normal use of a laser or laser system.

**Accommodation**

The ability of the eye to change its power and thus focus for different object distances.

**Aperture**

An opening through which radiation can pass.

**Apparent visual angle($\alpha$)**

The angular subtense of the source as calculated from the source size and distance from the eye. It is not the beam divergence of the source.

**Attenuation**

The decease in the radiant flux of any optical beam as it passes through and absorbing and/or scattering medium.

**Aversion response**

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

**Beam diameter**

The distance between diametrically opposed points in the cross section of a circular beam where the power-per-unit area is 1/e or 37% of the peak.

**Beam divergence**($\phi$)

Angle of beam spread measured in radians or milliradians (1 milliradian = 3.4 minutes-of-arc or approximately 1 mil). For small angles where the chord is approximately equal to the arc, the increase in the diameter of the beam is numerically equal to 1/1000th of the range in meters multiplied by the number of milliradians of beam divergence. That is, at 1000 meters range, a beam divergence of 2 milliradians would produce a beam diam eter 2 meters wider than the emergent beam diameter.

**Beam splitter**

An optical device using controlled reflection to produce two beams from a single incident beam.

**Classification duration (Tmax)**

The maximum duration of exposure inherent in the design of the laser device. For a Class 2 laser, this is 0.25 second.

**Closed installation**

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

**CW Laser**

Continuous-wave laser, as distinguished from a pulsed laser. A laser emitting for a period in excess of 0.25 second.

**Controlled area**

An area where the occupancy and activity of those within are subject to control and supervision for the purpose of protection from optical radiation hazards.

**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 (or the 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 of irradiance is 1/e of the maximum value. For the purpose of this guide, divergence is taken as the full angle expressed in radians], or the change in beam diameter measured between those points which includes the radiant exposure or irradiance equal to 1/e of the maximum value. The angular extent of a beam which contains all the radius vectors of the polar curve of radiant intensity having length rated at 36.8% of maximum. Sometimes this also referred to as "beam spread," but the two are not always equivalent.)

**Duty cycle**

Ratio of "on" duration to total exposure duration for a repetitively pulsed laser. Also, the product of the pulse duration and the PRF.

**Electromagnetic radiation**

The propagation of varying electric and magnetic fields through space at the velocity of light.

**Emergent beam diameter (a)**

Diameter of the laser beam at the exit aperture of the system in centimeters (cm) defined at 1/e-peak irradiance points.

**Enclosed laser device**

Any laser or laser system located within an enclosure that does not permit hazardous optical radiation emission from the enclosure. The laser inside termed an "embedded laser."

**Energy (Q)**

The capacity for doing work. Energy is commonly used to characterize the output from pulsed lasers, and it is generally measured in joules (J).

**Exempted laser product**

In the United States, a laser device exempted by the U.S. Food and Drug Administration from all or some of the requirements of 21 CFR 1040.

**Extended source**

An extended source of radiation that can be resolved by the eye of an observer into a geometrical image in contrast with a point source of a

radiation, which cannot be resolved into a geometrical image. For the purposes of this document, a source which subtends an angle greater than $\alpha$ min.

**Gas laser**

A type of laser in which the laser action takes place in a gas medium, usually operated as a CW laser.

**Hertz(Hz)**

Unit of frequency, i.e. "cycles per second."

**Infrared (IR) radiation**

Electromagnetic radiation with wavelengths that lie within the range of 0.76 to 0.78-1000 μ m. This region is often broken up into IR-A (0.76 to 0.78-1.4μ m), IR-B (1.4-3μ m), and IR-C (3μ m to 1μ m). For convenience in this guide, wavelength greater than 0.7 μ m and less than 1mm.

**Integrated radiance (Lp)**

Product of the exposure duration times the radiance. Also known as pulsed radiance ($W \bullet s \bullet cm^{-2}$).

**Intrabeam viewing**

The viewing condition whereby the eye is exposed to all or part of a laser beam. (See Figure B-3 and B-4b of Appendix B.)

**Irradiance (E)**

Radiant flux per unit area upon a given surface. Units: watts per square centimeter ($W \bullet cm^{-2}$).

**Joule**

A unit of energy normally used in describing a single-pulsed output of a laser; it is equal to one watt-second or 0.239 calorie.

**Joule$\bullet$ cm$^{-2}$ (J$\bullet$ cm$^{-2}$)**

A unit of radiant exposure used in measuring the amount of energy per unit area of absorbing surface or per unit area of a laser beam.

**Lambertiam surface**

An ideal diffuse surface whose emitted or reflected radiance (brightness) is independent of the viewing angle.

**Laser**

A source of an intense, coherent, directional beam of optical radiation. Also, and acronym for: Light Amplification by Stimulated Emission of Radiation. A laser usually is composed of an energy source, a resonant cavity, and an active lasing medium.

**Laser device**

Either a laser or a laser system.

**Laser system**

An assembly of electrical, mechanical, and optical components that includes a laser.

**Laser-controlled area**

Any area which contains one or more lasers and in which the activity of personnel is subject to control and supervision.

**Light**

Visible radiation. In this guide, wavelengths between 400 and 700 nm. The Commission International de l'Eclairage (International Commission on Illumination) define this spectral region as 380-400 nm to 760-780 nm.

**Limiting angular subtense $\alpha_{min}$**

The apparent visual angle which divides intrabeam viewing from extended-source viewing.

**Limiting aperture**

The maximum circular area over which irradiance and radian exposure can be averaged.

**Micrometer ($\mu$ m)**

Formerly termed "micron," a measure of length equal to $10^{-9}$ meters = 1000 nanometers.

**Nanometer (nm)**

Unit of length equal to $10^{-9}$ m or 0.001 μ m.

**Nominal Hazard Zone (NHZ)**

Describes the space within which level of the direct reflected or scattered radiation during normal operation exceeds the applicable TLV level.

**Nominal Ocular Hazard Distance**

The axial distance of the unobstructed beam from the laser to the human eye where the radian exposure of irradiance falls below the applicable TLV. See Appendix B, Example 18.

**Open installation**

Any location where lasers are used which will be open to operating personnel during laser operation and may or may not specifically restrict entry to nonessential personnel.

**Optical density (OD)**

The logarithm to the base (10) of the attenuation produced by an attenuating medium, such as an eye protection filter. $OD = \log [E_o / E_t]$ where $E_o$ is the incident irradiance and $E_o$ is the transmitted irradiance and $E_t$ is the transmitted irradiance at a specific wavelength ($\lambda$ ).

**Optical radiation**

UV, visible, and IR radiation (100nm to 1mm).

**Optical pumped lasers**

A type of laser that derives energy from an other light source such as xenon flash lamp (coherent light sources, i.e., other lasers, have also been used.)

**Output power and output energy**

The laser output power is used primarily to rate CW lasers since the energy delivered per unit time remains relatively constant (output measured in watts). In contrast, pulsed lasers deliver their energy impulses in pulses, and their effects may best be categorized by energy output per pulse. (The pow**r** output level of Cw lasers is usually expressed in milliwatts (mW=1/1000 watt) or watts; pulsed lasers in the megawatt

(MW=million watts) or gigawatt [GW= billion watts] range.) Pulsed energy output is usually expressed in joules (or millijoules [1mJ=1/1000 J]) per pulse.

**Photosensitizers**

Substances which increase the sensitivity of the skin or eye to irradiation by optical radiation, usually to UV.

**Point source**

Ideally, a source with infinitesimal dimensions. Practically, a source of radiation whose dimensions are small compared with the viewing distance. For this guide, a source which subtends an angle at the viewer less than $\alpha$ min.

**Power ($\Phi$ )**

The time rate at which energy is transferred. Usually expressed in watts (joules per second); also termed *radiant flux*.

**PRF**

Abbreviation for pulse repetition frequency. These units are hertz (Hz) or pulses-per-second.

**Protective housing**

A device designed to prevent access to radiant power or energy at levels higher than the intended classification limits.

**Pulse duration**

Duration of coherent optical radiation emission from a pulsed laser flash. Pulse duration may be measured in terms of milliseconds (ms = $10^{-3}$ s), microseconds, ($\mu$ =$10^{6}$ s), or nanoseconds (ns = $10^{-9}$) as defined by half-peak power points on the leading and trailing edges of the pulse.

**Pulsed laser**

A laser delivers its energy in one or more short pulses, as distinguished from a CW laser. For the purpose of this guide, a laser which emits bursts of energy for less than 0.25 second. The pulses may be repeated and may be comprised of a train of shorter duration pulses on occasion.

**Q-switched laser**

Also known as Q-spoiled– – A laser capable of extremely high peak power for very short duration's (pulse duration of several nanoseconds).

**Radian**

A unit of angular measure equal to the angle subtended at the center of a circle by a chord whose length is equal to the radius of the circle. (1 radian=57.3 degrees or $2\pi$ radians= 360 degrees.)

**Radiance (L)**

Radiant flux (or power) output per unit solid angle per unit area usually expressed in $W \bullet sr^{-1} \bullet cm^{-2}$ .

**Radiant energy (Q)**

Energy in the form of electromagnetic waves usually expressed in units of joules (watt-seconds). In this guide, the power emitted by a laser.

**Radiant exposure (H)**

The total energy per unit area incident upon a given surface in a given time interval. It is used to express exposure to pulsed laser radiation and is commonly expressed in $J\ cm^{-2}$.

**Radiant flux or radiant power ($\Phi$ )**

The time rate of flow of radiant energy. Units: watts.(1 watt = $1\ J \bullet s$ ).

**Radiant intensity (I)**

of a source in a given direction– – Radiant flux emitted from the source per unit solid angle (steradian), in the direction of propagation, usually expressed in $W \bullet sr^{-1}$.

**Rayleigh scattering**

Scattering of radiation in the course of its passage through a medium containing particles, the sized of which are small compared with the wavelength of the radiation.

**Reflectance or Reflectivity**

The ration of reflected radiant flux to incident radiant flux.

**Repetitively pulsed laser**

A pulsed laser with reoccurring pulsed output. The frequency of the pulsed is termed pulsed repetition frequency (PRF). Repetitively pulsed laser have properties similar to a CW laser if the PRF or duty cycle is very high.

**Scintillation**

This term is used to describe the rapid changes in irradiance levels in a cross section of a laser beam produced by atmospheric turbulence.

**Secured enclosure**

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

**Semiconductor or injection laser**

A class of lasers which at present produce relatively low CW power outputs. Also known as a "diode laser." Similar to a light-emitting diode, except that the optical radiation emission is coherent and more monochromatic.

**Service**

Performance of adjustments, repair, or procedures required to return the equipment to its intended state. Service may adversely affect the classification of equipment.

**Solid angle (½)**

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**

Term taken to mean either a laser or laser-illuminated reflecting surface in this guide.

**Steradian (¹)**

The unit of measure for a solid angle. There are 4 ¹steradians in a sphere.

**Transmittance (transmissivity) (τ )**

The ratio of total transmitted radiant power to total incident radiant power.

**Ultraviolet (UV) radiation**

Electromagnetic radiation with wavelengths between soft X-rays and visible violet light, often broken down into UV-A(315-400nm), UV-B (280-315 nm), and UV-C (100-280nm). UV radiation of wavelengths less than 180nm are transmitted very poorly through air.

**Visible radiation (light)**

Electromagnetic radiation which can be detected by the human eye. It is commonly used to describe wavelengths which lie in the range between 400 and 700-780 nm.

**Watt (W)**

the unit of power, or radiant flux; 1 $J \bullet s^{-1}$.

**Watt$\bullet$ cm $^{-2}$(W$\bullet$ cm$^{-2}$)**

A unit of irradiance used in measuring the amount of power per area of absorbing surface, or per cross-sectional area of CW laser beam.

**Wavelength ($\lambda$ )**

The distance between two points in a periodic wave that have the same phase is termed one wavelength. C, the speed of light ($3\times 10^{10}$ cm$\bullet$ $s^{-1}$) divided by the frequency (Hz) equals wavelength (cm).