



## **LASER TERMS GLOSSARY**

## LASER TERMS GLOSSARY

**Introduction** - This section lists information pertinent to laser safety. The definitions in this glossary will not cover every term associated with lasers but does cover a majority of the terms. If a term should be encountered in your work with lasers and is not in this glossary, consult your supervisor or call the Texas State University Risk Management and Safety Office.

### Laser Terms

**ABSORPTION:** means the transformation of radiant energy to a different form by interaction with matter.

**ACCESS CONTROL:** Entry must be restricted to authorized laser personnel during the operation of laser equipment.

**ACCESSIBLE EMISSION LIMIT (AEL):** - means the maximum accessible emission level permitted within a particular class.

| WAVELENGTH<br>( $\mu\text{m}$ ) | DURATION<br>(s) | CLASS 1<br>(W)   | CLASS 2<br>(W)           | CLASS 3a<br>(W)                 | CLASS 3b<br>(W)              | CLASS 4<br>(W) |
|---------------------------------|-----------------|--|--------------------------|---------------------------------|------------------------------|----------------|
| <b>Ultraviolet</b>              |                 |  |                          |                                 |                              |                |
| 0.18 to 0.302                   | $3 \times 10^4$ | $\leq 9.6 \times 10^{-9}$                              | -                        | Between 1 to 5<br>times Class 1 | > Class 3a but<br>$\leq 0.5$ | > 0.5          |
| 0.302 to 0.4                    | $3 \times 10^4$ | $\leq 3.2 \times 10^{-6}$                              |                          |                                 |                              |                |
| <b>Visible</b>                  |                 |  |                          |                                 |                              |                |
| 0.4 to 0.7                      | 10              | $\leq 0.4 \times 10^{-3}$                              | > Class 1<br>but < 0.001 | Less than 5<br>times Class 2    | > Class 3a but<br>$\leq 0.5$ | > 0.5          |
| <b>Near IR</b>                  |                 |  |                          |                                 |                              |                |
| 0.7 to 1.05                     | $\geq 10$       | $\leq 0.4 \times 10^{-3}$<br>to $< 1.9 \times 10^{-3}$ | -                        | Between 1 to 5<br>times Class 1 | > Class 3a but<br>$\leq 0.5$ | > 0.5          |
| <b>IR</b>                       |                 |  |                          |                                 |                              |                |
| 1.05 to 1.15                    | $\geq 10$       | $\leq 1.9 \times 10^{-3}$                              | -                        | Between 1 to 5<br>times Class 1 | > Class 3a but<br>$\leq 0.5$ | > 0.5          |
| 1.15 to 1.2                     |                 | $\leq 1.9 \times 10^{-3}$<br>to $1.5 \times 10^{-2}$   |                          |                                 |                              |                |
| 1.2 to 1.4                      |                 | $\leq 1.5 \times 10^{-2}$                              |                          |                                 |                              |                |
| <b>Far IR</b>                   |                 |  |                          |                                 |                              |                |
| 1.4 to 100                      | $\geq 10$       | $\leq 9.6 \times 10^{-3}$                              | -                        | Between 1 to 5<br>times Class 1 | > Class 3a but<br>$\leq 0.5$ | > 0.5          |

**AGENCY:** means the Texas Department of State Health Services Radiation Control agency.

**AVERAGE POWER:** means the total energy imparted during exposure divided by the exposure time .

**AVERSION RESPONSE:** means the movement of the eyelid or the head to avoid an exposure to a noxious stimulant or bright light. It can occur within 0.25 seconds, including blink reflex time .

**APERTURE:** means any opening in the protective housing or other enclosure of a laser product through which laser radiation is emitted, thereby allowing human access to such laser radiation.

**ATTENUATION:** means the decrease in the radiant flux as it passes through an absorbing or scattering medium.

**BEAM:** means a collection of rays, which may be parallel, divergent or convergent.

**BEAM DIAMETER:** means the distance between diametrically opposed points in the cross-section of a beam where the power per unit is 1/e times that of the peak power per unit area.

**BEAM DIVERGENCE (O):** means the full angle of the beam spread between diametrically opposed 1/e irradiance points; usually measured in milliradians (one milliradian is approximately 3.4 minutes of arc).

**BEAM EXPANDER:** means any combination of optical elements, which can increase the diameter of the laser beam. Laser beam expansion is always accompanied by a proportional decrease in laser beam divergence.

**BEAM SPLITTER:** means an optical device that uses controlled reflection to produce two beams from a single incident beam.

**Class 1** - Any laser or laser system that does not permit access during operation to levels of laser radiation in excess of the applicable accessible emission limits.

**Class 2** - Any laser or laser system that permits human access during operation to levels of visible laser radiation in excess of Class 1 AELs, but does not permit human access during operation to levels of laser radiation in excess of Class III AELs.

**Class 3a** - Any laser or laser system that has an accessible output between 1 and 5 times the Class 1 AELs shorter than 0.4  $\mu\text{m}$  or longer than 0.7  $\mu\text{m}$ , or less than 5 times the Class 2 AELs between 0.4  $\mu\text{m}$  and 0.7  $\mu\text{m}$ .

**Class 3b** - Any laser or laser system that has an accessible output between in excess of Class 3a AELs shorter than 0.4  $\mu\text{m}$  or longer than 0.7  $\mu\text{m}$ , or excess of Class 3a AELs between 0.4  $\mu\text{m}$  and 0.7  $\mu\text{m}$ .

**Class 4** - Any laser or laser system that has an accessible output between in excess of Class 3 AELs. As would be expected, these lasers may be either a fire or skin hazard or a diffuse reflection hazard. Very stringent control measures are required for a Class 4 laser or laser system.

**CO-2 LASER** - wavelength 10.6 micrometers (far infrared, invisible).

## LASER TERMS GLOSSARY

**COLLIMATED BEAM:** a “parallel” beam of light with very low divergence or convergence.

**CONTINUOUS WAVE (cw):** - means the output of a laser, which is operated in a continuous rather than pulse mode for a period greater than 0.25 seconds.

**CONTROLLED AREA:** means an area where the occupancy and activity of those within are subject to control and supervision for the purpose of protection from radiation hazards.

**DIFFRACTION:** means the deviation of a part of a radiation beam, determined by the wave nature of the radiation, and occurring when the radiation beam passes the edge of an opaque obstacle.

**DIFFUSE REFLECTION:** means the change of the spatial distribution of a beam of radiation when it is reflected in many directions by a surface or by a medium .

**EMERGENT BEAM DIAMETER (a)** - means the diameter of the laser beam at the exit aperture of the laser product. Measured in centimeters (cm).

**ENCLOSED LASER:** a laser that is imbedded in an instrument with engineering features limiting access to the laser radiation. The laser product can contain an enclosed laser with an assigned class number higher than the inherent capability of the laser product in which it is incorporated.

**ENERGY (Q)** - means the capacity for doing work. Energy content is commonly used to characterize the output from pulsed laser products and is generally expressed in joules (J).

**ENERGY DENSITY:** means the emittance (M) or irradiance (E) of electromagnetic radiation, energy per unit area, e.g., joules meter<sup>2</sup> or joules/centimeter<sup>2</sup> .

**EXPOSURE:** means the product of an irradiance (E) and its duration.

**GAS LASER:** means a type of laser where the laser action takes place in a gaseous medium .

**Helium-Neon (HeNe) Laser - red aiming beam.** Wave length 632.8 nanometers

**HERTZ (Hz)** - means the unit, which expresses the frequency of a periodic oscillation in cycles per second.

**HUMAN ACCESS:** means access at a particular point to laser or collateral radiation by any part of the human body or by an object. A laser product or installation shall be considered to permit human access if radiation in excess of an accessible emission limit is incident at a point that can be reached by a straight object 3.0 + 0.1 millimeters in diameter and 10.0 + 0.1 centimeters in useful length .

**INCIDENT:** means an unusual event or occurrence.

**INFRARED RADIATION:** - means the electromagnetic radiation with wavelengths that lie in the 0.7 micrometer to 1 millimeter range.

**INSTALLATION:**- means any location where one or more products are used or operated.

**INTENSITY:** means the amount of energy or energy per unit time passing through a unit area perpendicular to the line of propagation at the point in question.

**INTRABEAM VIEWING:** means the viewing condition whereby the eye is exposed to all or part of a laser radiation beam.

**IRRADIANCE (E):** means the quotient of the radiant power incident on an element of a surface by the area of that element, expressed in watts per square centimeter (W/cm<sup>2</sup>).

**JOULE (J)** - means a unit of energy, one J = 1 Watt/second .

**LASER:** Light Amplification by Stimulated Emission of Radiation. A device which generates or amplifies electromagnetic oscillations in the spectral region between the far infrared (submillimeter) and ultraviolet . The laser consists of an amplifying (active or casing) medium and a regenerative of feedback device (resonant cavity). The amplifying medium can be gas, solid, or liquid. Two end mirrors generally bound the feedback medium. The laser light produced is of high intensity, high monochromaticity, small beam divergency (collimated), and is phase coherent.

**LASER CONTROLLED AREA:** means any area which contains one or more lasers and in which the activity of personnel is subject to control and supervision for the purpose of protection from laser radiation hazards.

**LASER PROTECTIVE DEVICE:** means any device, the intended function of which is the control of laser radiation with the intent of reducing or eliminating the exposure of personnel to such radiation.

## LASER TERMS GLOSSARY

**LASER RADIATION:** means all electromagnetic radiation, which is produced as a result of controlled stimulation emission.

**Laser Safety Officer (LSO)** - means any individual, qualified by training and experience in occupational and public health aspects of lasers, who is designated to evaluate the radiation hazard of and to establish, administer, and be responsible for, laser radiation protection. At Texas State University – San Marcos this is the Radiation Safety Officer (LSO)

**LASER SYSTEM:** - means a laser in combination with an appropriate laser energy source with or without additional incorporated components.

**LASING MEDIUM:** means a material emitting coherent radiation by virtue of stimulated electronic or molecular transitions to lower energy levels.

**LIMITING APERTURE:** means the maximum circular area over which radiance or radiant exposure can be averaged.

**MAINTENANCE:** means the 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 insure the intended performance of the product. It does not include “operation” or “service” as defined in this section.

**MAXIMUM EMISSION DURATION:** means the maximum duration of repeated, or continuous operation of which the laser product is capable, whichever is greater.

**MAXIMUM OUTPUT:** means that maximum magnitude of energy or power, at any time after manufacture, of total accessible laser radiation emitted by a laser product over the full range of operational capability.

**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. The maximum permissible exposures for lasers radiation may be found in ANSI Z136.1-2000, Safe Use of lasers.

**MEDICAL LASER PRODUCTS:** means any laser product designed or intended for purposes of in vivo diagnostic or therapeutic laser irradiance of any part of the human body.

**Neodymium.Yttrium Aluminum Garnet (Nd.YAG) Laser** - wavelength (A) 1064 nanometers.

**NOMINAL HAZARD ZONE (NHZ):** means 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.

**NOMINAL OCCULAR HAZARD DISTANCE (NOHD) -** means the distance along the axis of the unobstructed beam from the laser to the human eye beyond which the irradiance or radiant exposure during normal operation is not expected to exceed the appropriate MPE.

**OPERABLE LASER:** means a laser that can produce laser radiation.

**OPERATION:** means the performance of the laser or laser system over the full range of its intended functions (normal operation). It does not include "maintenance" or "service" as defined in this section.

**OPTICAL DISTANCE (D) :** means the logarithm to the base ten of the reciprocal of the transmittance.

**OUTPUT POWER AND OUTPUT ENERGY:** means the laser output power used primarily to rate CW lasers since the energy delivered per unit time remains constant (output measured in watts). In contrast, pulsed lasers deliver energy in pulses and their effects can be best categorized by energy output per pulse.

**POWER (P) :** means the time rate at which energy is emitted, transferred, or received; usually expressed in watts.

**PROTECTIVE HOUSING:** An enclosure surrounding the laser that prevents access to laser radiation above the applicable MPE level. The aperture through which the useful beam is emitted is not part of the protective housing. The protective housing may enclose associated optics and a work station and shall limit access to other associated radiant energy emissions and to electrical hazards associated with components and terminals.

**PULSE DURATION:** means the time increment measured between the half-peaks-power points of the leading and trailing edges of the pulse.

**PULSE REPETITION FREQUENCY (PRF) :** means the number of laser pulses per unit time (usually expressed in seconds).

**PULSED LASER:** means a laser which delivers its energy in the form of a single pulse or a train of pulses, where the duration of a pulse is less than or equal to 0.25 seconds.

## LASER TERMS GLOSSARY

**Q-SWITCH:** means a device for producing very short (approximately 30 nanoseconds), intense laser pulses by enhancing the storage and dumping of electronic energy in and out of the basing medium, respectively.

**Q-SWITCHED LASER:** means a laser, which emits short (approximately 30 nanoseconds), high-power pulses by utilizing a Q-switch.

**RADIANCE (L):** means radiant power per unit area of radiation surface per unit solid angle of emission, expressed in watts per square centimeter per steradian ( $\text{w/cm}^2/\text{Sr}$ ).

**RADIANT ENERGY (Q):** means energy emitted, transferred or received in the form of radiation, expressed in joules (J).

**RADIANT EXPOSURE (H):** means the quotient of radiant energy incident on an element of a surface by the area of that element, expressed in joules per square centimeter ( $\text{J/cm}^2$ ).

**RADIANT INTENSITY (I) (of a source in a given direction):** means the quotient of the radiant flux leaving the source, propagated in an element of solid angle containing the given direction, by the element of solid angle. Expressed in watts per steradian ( $\text{w/Sr}$ ).

**RADIANT POWER:** means power emitted, transferred or received in the form of radiation, expressed in watts (W).

**REFLECTANCE, REFLECTIVITY (P):** means the ratio of total reflected radiant power to total incident power.

**REFLECTION:** means the deviation of radiation following incidence on a surface.

**REMOTE CONTROL CONNECTOR:** means a two-terminal connector which permits the connection of external controls placed apart from other components of the laser product to prevent human access to all laser and collateral radiation in excess of limits specified.

**SAFE EYE EXPOSURE DISTANCE (SEED):** means the distance from an operating laser such that the energy that might infringe upon the eye is less than the MPE.

**SAFETY INTERLOCK:** means a device associated with the protective housing or enclosure of a laser product to prevent human access to excessive radiation under conditions specified.

## LASER TERMS GLOSSARY

**SERVICE:** means the performance of those procedures or adjustments described in the manufacturer's service instructions, which may affect any aspect of the performance of the laser or laser system. It does not include "maintenance" or "operation" as defined in this section.

**SHALL:** the word "shall" is understood to mean mandatory.

**SHOULD:** the word "should" is understood to mean that which is advisable.

**SOURCE:** means the term used to describe either a laser or laser-illuminated reflecting surface.

**SPECULAR REFLECTION:** means a mirror-like reflection.

**TRANSMISSION:** means the passage of radiation through a medium.

**TRANSMITTANCE:** means the ratio of total transmitted radiant power to total incident radiant power.

**ULTRAVIOLET RADIATION:** means the electromagnetic radiation with wavelengths shorter than those for visible radiation (0.2 - 0.4 micrometers). This region is often broken down into three spectral bands by wavelength: VV-A (315 - 400 nanometers), UV-B (280 - 315 nanometers), and UV-C (200 - 280 nanometers).

**UNRESTRICTED AREA:** means any area to which access is not controlled for the purposes of protection of individuals from exposure to radiation.

**VAPORIZATION:** means the conversion of a solid or liquid into vapor.

**VISIBLE RADIATION (LIGHT):** means all electromagnetic radiation, which can be detected by the human eye. It is commonly used to describe wavelengths, which lie in the range between 0.4 micrometers and 0.7 micrometers.

**WATT (W):** means a unit of power, or radiant flux.

**WAVELENGTH:** means only the propagation wavelength in air of electromagnetic radiation.