Laser safety

The laser can be included among the sources of non-ionizing radiation, however for its massive consumption and now widespread at all levels of scientific experimentation, it certainly deserves special consideration.

Laser is the well-known acronym for Light Amplification by Stimulated Emission of Radiation, the physical process behind intense, coherent and directional electromagnetic radiation that can be ultraviolet (200-400nm), visible (400-700nm), or infrared (700nm- 1 millimeter). The risks associated with the use of lasers are both those related to the intrinsic characteristics of the beam, and those deriving from the equipment that create and maintain this type of radiation. Direct interaction with the beam particularly affects the eyes and skin.

The safety measures and the means of control to be put in the development and modification of the laser and / or laser equipment are specific in the CEI file 1381G standard called "Guide for the use of laser equipment for research laboratories". This standard joins the CEI 76-2 standard concerning the safety of radiation from laser devices.

DEFINITION AND CLASSIFICATION

The wide variety of wavelengths, applications, energies and impulse characteristics of lasers and systems that include lasers make it essential, for safety purposes, to group them into categories, or classes, of hazard. The introduction of a new parameter called the Acceptable Emission Limit (LEA), which describes the levels of radiation emerging from a laser system, whose evaluation allows the placement of the device in the appropriate risk category, was very useful. The determination of the LEA must be carried out in the most unfavorable conditions for safety purposes. 5 classes have been identified: 1, 2, 3A, 3B and 4, with an increasing hazard index with the class number.

- Class 1: lasers that are always safe as the radiation emitted is below the maximum allowed standards;

- Class 2: lasers that emit visible radiation in the wavelength range between 400 and 700 nm. Eye protection is normally ensured by defense reactions, including the eyelid reflex. Continuous emission visible light lasers with power ≤1mW are included in this class;

- Class 3A: laser with visible emission and an output power up to 5mW for continuous lasers, or 5 times the class 2 limit for repeated pulse or scanning lasers. They can emit radiation both in the field of the visible and non-visible and their beams are not dangerous if observed directly in a non-continuous way, while they can become so if instruments that amplify and concentrate the optical beam are used;

- Class 3B: lasers with average powers between class 3A and 500mW. They are laser dangerous for the eyes if not protected and can be dangerous for the skin. Even the reflections spread by these systems can be dangerous;

- Class 4: very dangerous high power lasers capable of producing serious damage to eyes and skin even if the beam is diffused. They are potential fire risk. They can cause the escape of toxic material and often the voltage and the amperage of the power supply are dangerously high. Their use requires extreme caution.

SECURITY REQUIREMENTS

From what has been said above, there is a clear need for adequate safety measures for the type of equipment. In general we will distinguish the safety requirements that must be provided for Class 2 lasers and the necessary requirements for those of Classes 3A, 3B and 4:

Class 2

Precautions must be taken to avoid parking in the direction of the beam or beam reflected from a surface. A temporary exposure (0.25 s), which could occur during an inspection, is not considered dangerous. For class 2 lasers the following requirements must be respected:

1) The laser must never be directed towards a person's eyes;

2) A warning sign with the wording "ATTENTION - DO NOT STAY NEAR THE LASER BEAM" must be positioned in an evident point on the laser;

3) All observation inputs and observation screens intended as parts of the laser, as well as the connected optics (lenses, microscopes etc) used as an observation point, must

incorporate connections, filters, attenuators or other devices designed to maintain radiation at safety levels during all use and maintenance situations. New class 3A laser installations if observed with collection optics (microscopes, binoculars, etc.), and class 3B or 4 must be approved in advance by a responsible technician who has the necessary knowledge to evaluate and control the risks caused by lasers and has supervisory responsibility for controlling these risks. Therefore it is good, before proceeding with a new installation of a laser, carefully evaluate the environmental conditions in relation to the instrument and its potential danger.

Class 3

These lasers are potentially dangerous if the beam, directed or reflected from a surface (watches, pen rings, ..), is intercepted by an unprotected eye. These requirements must be followed, in addition to those already mentioned for class 2:

1) The beam must be blocked at the end of its useful path by a material of a color that allows positioning of the beam with minimal reflection;

2) Lasers should be used in controlled access locations;

3) Eye protection is necessary if it is possible that the eye may accidentally intercept the beam;

4) Medical surveillance is required to prevent or highlight possible eye damage;

5) All parts of the housing which, during maintenance operations, are removed, thus allowing access to radiation, must be provided with safety connections (to prevent access to the interior during operation).

Class 4

For this class, it is necessary to prevent eye damage resulting from any reflection of the beam, as well as the possible risks of fire and damage to the skin. The precautions to be taken must include a project that controls the entire path of the beam. The safety measures to be adopted, always in addition to those previously stated, are:

1) The laser must be used in a controlled access area: safety closures must be provided to avoid unauthorized entry into the operating area, and access must be limited to people who wear PPE for eye protection when the laser is operating;

2) To ensure maximum protection in the controlled area, the entire path of the beam, including the radiation area, must be closed. Appropriate structures must be installed around the system that prevent excessive approach to the beam, and with connections such that the laser cannot operate without them;

3) For pulsed systems these connections must be designed in such a way as to prevent the laser from burning, discharging the stored energy. For continuous wave lasers, the safety devices must switch off the beam power supply or interrupt the beam by means of closures;

4) The lasers must be provided with a safety key or an on / off device. The key must be kept by an authorized person;

5) The lasers will be equipped with a beam blocking or attenuation system;

6) During activation or the start-up procedure the following must be used: alarm system, signal light, countdown command. This reporting system will be activated before issuing, in order to allow you to take the appropriate measures to avoid exposure to the laser;

7) Written procedures must be available for aligning the beam, its use and maintenance;

8) Staff must undergo medical surveillance to prevent or highlight possible eye damage.

OTHER PREVENTION MEASURES

Whenever laser operations are carried out, standard protective glasses must be worn (the most effective thing is to leave at least a couple of them in the operating area). Pay attention to the fact that different wavelengths require different protective glasses. The frequency range for which it is suitable is indicated on this type of PPE, check that it is compatible with the equipment in question. Visual signals: appropriate warning signs must be highlighted on the laser system. Specific reports must be placed outside the operating area. The "WARNING" signal must be used in all the signs associated with class 2 lasers and the "DANGER" signal must be used in all the signs associated with class 3 and 4 lasers.

CLASS	INDICATION
3A	LASER RADIATION DO NOT FIX THE BARE EYE BEAM OR LOOK DIRECTLY WITH OPTICAL INSTRUMENTS CLASS 3A LASER APPARATUS
3B	LASER RADIATION AVOID EXPOSURE TO THE BEAM CLASS LASER APPARATUS 3B
4	RADIATION OF POSSIBLE RADIATION DIRECT OR DIFFUSED CLASS 4 LASER APPLIANCE

ASSOCIATED HAZARDS

Contamination of the atmosphere - gases or vapors from laser gas circulation systems, or from intermediate products of laser reactions, gases or vapors from cryogenic agents.

Ultraviolet, visible or infrared radiation - due to flash lamps, discharge tubes, pumping sources or return radiation.

Electrical Hazards - derived from the use of high voltage and energy stored in the capacitors of pulsed lasers.

Cryogenic agents - risks associated with the use and handling of cryogenic liquids.

Fire or combustion hazards - this risk may persist even at a great distance from the laser apparatus due to the interaction of the beam with flammable substances.

Explosions - there is the possibility of explosions in the capacitor bank or in the optical pumping systems as well as explosive reactions of reagents in chemical lasers or other lasers used in the laboratory.