

Safety of laser devices

The safety of laser devices is regulated by “good practice” regulations consisting of the CEI EN 60825-1 (2003) standards which includes a part for research laboratories.

Protection

Room

To avoid unwanted reflections, the features of the optical bench and the area of the wall that could be hit must have anti-reflective surfaces. The lighting must be at high intensity in order to decrease the papillary radius.

Access to the room

In addition to the prescription signs, the outside of the room must be equipped with a flashing signal light with the words “laser in use” activated by means of the general switch of the emitter. The doors should be equipped with juxtaposing microswitches which, when the door is opened with the laser on, activate an acoustic signal.

Control key operation

Class 3B or 4 lasers must be protected from unauthorized use by removing the control key.

Beam path

The beam should be segregated within semi-fixed protections connected with microswitches for the entire path, in such a way that their removal, even if partial, causes the closure of a shutter, placed in front of the emitter, which intercepts the beam and which can only be reopened manually at a later time. The beam must not be at eye level.

Individual protections

Goggles and filter screens must be suitable for the wavelength of the laser. If skin-hazardous levels are exceeded or if fire hazards are present, appropriate clothing is required.

Safety precautions

All lasers are classified by the manufacturer according to the maximum accessible radiation level (ARL) and based on this figure there are different levels of protection. Prototypes and devices undergoing modifications that may affect the classification must be examined and categorized by the research/teaching responsible of the laboratory (RDRL).

Class 1 laser devices do not carry any prescriptions.

For classes 1M, 2 and 2M, precautions are required only to prevent continuous observation of the direct beam; a temporary exposure (0.25 s) to radiation in the wavelength range from 400 nm to 700 nm, which could occur in instances of accidental observation, is not considered dangerous. However, the laser beam should not be intentionally aimed at people.

Class 1M laser devices

- Do not look directly at the beam
- Use specific precautions for non-visible laser light
- Observation optics at a distance of less than 100 mm must be equipped with safety devices (filters, attenuators, etc.)

Class 2 laser devices

- Do not look directly at the beam
- Use specific precautions for non-visible laser light

Class 2M laser devices

- Do not look directly at the beam
- Use specific precautions for non-visible laser light
- Observation optics at a distance of less than 100 mm must be equipped with safety devices (filters, attenuators, etc.)

Class 3R laser devices

For class 3R lasers in the wavelength range below 400 nm and above 700 nm, luminous warning signs with automatic switch-on device must be used. Any visual warning devices must be clearly visible through the eye shields. For prototypes, verbal warning signs or light signals activated by the operator himself may be temporarily allowed (subject to the authorization of the teaching/research responsible of the laboratory).

- Avoid direct exposure of the eyes in the wavelength range between 400 nm and 1400 nm and avoid exposure to the laser beam for other wavelengths
- Use specific precautions for non-visible laser light
- Use observation optics (microscopes, lenses, ...) only if equipped with safety devices (filters, attenuators)

Class 3B laser devices

The precautions reported in the previous points must be observed; in addition:

- Use the laser only in areas controlled by the operators;
- Avoid specular reflections;
- Limit the beam with an object made of diffusing material of a color and reflectivity such as to allow adjustment of the position of the beam, in such a way as to minimize the dangers of reflection that exceed the maximum allowed exposure (MAE), which could cause damage to eyes or skin in the short or long term;
- Protect the eyes if it is possible to observe the beam directly or by reflection;
- Post a warning sign in accordance with the law at the entrance to the areas.

Class 4 laser devices

Direct vision, mirror reflections and diffuse reflections must be avoided. In addition to the precautions for the lower classes, it is therefore necessary to:

- Protect the beam path whenever possible, access during operation must be limited to technical personnel who use appropriate eye protectors and protective clothing;
- Use remote controls whenever possible;
- Take care of the internal lighting of the areas where the eye is protected (e.g light walls);
- In high-power lasers the fire hazard can be limited by a sufficient thickness of brick or other refractory material that can become bright following prolonged exposure, therefore non-flat metal targets adequately cooled such as cones and absorbers are preferable;
- Avoid unwanted reflections in the invisible part of the spectrum for laser radiation in the far infrared, the beam and the impact area should be surrounded by opaque material for the wavelength of the laser.

Labelling

Each laser must have a triangular yellow signal with the laser beam symbol in black. The plates must be permanently attached and be legible. Borders and graphics must be black on a yellow background. The text must be as follows:

Class 1	Class 1 laser device
Class 1M	Laser radiation – Do not observe directly with optical instruments – Class 1M laser device
Class 2	Laser radiation – Do not look at the beam – Class 2 laser device
Class 2M	Laser radiation – Do not look at the beam with the naked eye or observe directly with optical instruments – Class 2M laser device
Class 3R	Laser radiation – Avoid direct exposure of the eyes – Class 3R laser device
Class 3B	Laser radiation – Avoid exposure to beam – Class 3B laser device
Class 4	Laser radiation – Avoid eye or skin exposure to direct or scattered laser light – Class 4 laser device

Each panel that, once moved, allows human access to laser radiation, must bear a plate bearing the words "CAUTION - Laser radiation if opening" and also:

Class 1M	Caution – Class 1M laser radiation – Do not observe directly with optical instruments if opening
Class 2	Caution – Class 2 laser radiation – Do not look at the beam if opening
Class 2M	Caution – Class 2M laser radiation – Do not look at the beam with the naked eye or observe directly with optical instruments if opening
Class 3R	Caution – Class 3R laser radiation – Avoid direct exposure to beam if opening
Class 3B	Caution – Class 3B laser radiation – Avoid direct exposure to beam if opening
Class 4	Caution – Class 4 laser radiation – Avoid eye or skin exposure to direct or scattered laser light if opening

Complementary risks

Contamination of the atmosphere

Good ventilation or even capture of vapors in gas circulation systems may be necessary either due to intermediate reaction products (bromine, chlorine, fluorine, hydrogen cyanide) or to gases or vapors from cryogenic agents.

Collateral ultraviolet radiation

Risk related to the presence of flash lamps or the discharge tubes of continuous lasers, particularly if tubes or mirrors that transmit ultraviolet (eg quartz) are used.

Visible and infrared collateral radiation

It is emitted by flash lamps, pumping sources and radiation returning from the target.

Electrical dangers

Pulsed lasers and those that use voltages higher than 1 kV are particularly dangerous due to the energy stored in the capacitor banks. Around the power supply it is advisable to leave a space of at least 70 cm covered with insulating platforms to make interventions on high voltage parts safer. Circuit components such as electron tubes at anode voltages above 5 kV can emit X-rays and must therefore be shielded.

Cryogenic agents

The handling of these agents requires special precautions to avoid necrosis and injury.

Fire or Combustion Hazards

In case of interaction with flammable substances, especially during cuts, welds or punctures during which the target can emit incandescent particles.

Other risks

The capacitor bank and pumping systems can explode in high-power laser systems or due to particular reagents required in the use of chemical lasers.

Some pulsed lasers may present a noise risk.

Rules of conduct

- Personnel operating in laser research and development laboratories must be instructed on the risk associated with their use, also in consideration of the fact that the operation of class 3B and 4 lasers can also represent a danger for other people, at a considerable distance. The rules of conduct must be available for consultation in the workplace.
- The list, compiled by the Director, of the personnel authorized to use lasers must be posted outside the room. A laboratory manager must also be designated.
- The access of personnel not included in the list is permitted under the responsibility of the Director or other authorized person.
- Never look into the primary beam and protect your eyes during mandatory alignment operations.
- The training must include:
 - the basic principles and operation of the laser;
 - the procedures necessary to minimize risks, warning signs, etc. ;
 - knowledge of the risks associated with use and complementary risks;
 - the need to use personal protective equipment;
 - the procedures for reporting accidents;
 - the effects of the laser on the eyes and skin.