Rules for Laser-housing laboratories

1 Reference provisions

1.1 Set of rules on safety in working places

Hereafter the general provisions inherent the safety in working places are reported:

- D.P.R. 457/1956 – Norme per la prevenzione degli infortuni sul lavoro;
- D.P.R. n. 303/1956 – Norme generali per l'igiene del lavoro;
- D.Lgs. 19/9/1994 n. 626 – (Published in the Gazz. Uff. November 12th 1994, n. 265, S.O.);
- D.M. 05/08/1998, n. 363 – Application D. Lgs. 626/94 concerning the University ;
- D. Ret. N. 1113 November 17th 1999 – Regolamento di Ateneo per la sicurezza e la salute dei lavoratori.

1.2 Specific provisions

The specific safety rules concerning the use of laser are the following:

- Norma CEI EN 60825-1: classificazione delle apparecchiature, prescrizioni e guida per l'utilizzatore
  - Norma CEI 76 – CT 76 – File 3850 R – Guida utilizzazione apparati laser nei laboratori di ricerca;
  - Norma CEI 76-6 – CT 76 – File 5928: Guida all'uso degli apparati laser in medicina;
  - Norma CEI 76 – CT 76 – File 3849 R: Guida all'uso degli apparati laser in industria, telecomunicazioni, etc.
  - Norma CEI EN 60825-2: Sicurezza dei sistemi di telecomunicazione e fibre ottiche.
- Norma CEI EN 60825-4: Barriere per laser;
- Norma CEI EN 61040: rilevatori e misuratori potenza o energia;
- Norma UNI EN 207: protettori dell'occhio contro i laser;
- Norma UNI EN 208: protettori dell'occhio per regolazioni laser.

1.3 Definitions

In the present set of rules, the following definitions apply:

1. *Laser apparatus*. Every apparatus or group of components constituting, housing or designed to incorporate a laser or a laser system and that is not sold to another manufacturer to be used as a component (or as a spare part for a similar component) of an electronic device.
2. *Nominal distance of eye risk (DNRO)*. The distance at which the irradiation or the exposure to the energy of the beam is the same as the maximum allowed exposure (EMP) for the cornea.
3. *Extended nominal distance of eye risk*. The DNRO comprising the possibility of optically-assisted vision.
4. *Radiating energy*. The integral in time of the radiating power for a given length of the exposure time Δt. The relative expression is the following:

$$Q = \int_{\Delta t} \Phi dt$$

The symbol is Q, the unit measure is as joule (J).

5. *Exposure to energy*. The radiating energy incident on a surface element divided by the surface area of such an element:

$$H = dQ/dA = \int Edt$$

The symbol is H, the measure is as joule for square meter ($J \cdot m^2$).

6. *Maximum allowed exposure (EMP)*. The level of laser radiation to which, under normal conditions, people may be exposed without suffering of damage effects. The EMP levels are the maximum level to which the eye or the skin may be exposed without being affect by any short-term or long-term damage. Such levels depend on the radiation wavelength, on the duration of the pulse or on the exposure time, on the type of exposed tissue and with regard to the radiation at the visible or near infra-red wavelengths on the extent of the retinal image, (400-1400 nm).
7. *Exposure of humans*.
   a. The possibility that a part of the human body comes in contact with dangerous laser radiation given off through an opening or the possibility fore a straight probe with a diameter of 12 mm and a length of 80 mm to intercept laser radiation Class 2, 2M or 3R, or
   b. For levels of laser radiation inside the case exceeding the limits indicated in a., the possibility for any part of the human body to come in contact with dangerous laser radiation that can be reflected directly by any flat surface inside the apparatus through any opening of the safety case.
8. *Beam*. Laser radiation that can be characterized by direction, divergence, diameter or by scanning specifications. The scattered radiation of a reflection is not considered a beam;
9. *Radiating flux*. See under Radiating power.
10. *Irradiation*. The ratio between the radiating power $d\Phi$ incident on a surface element and the area dA of such an element:

$$E = d\Phi/dA$$

The symbol is E, the measure is as watt/square meter ($W \cdot m^2$).

11. *Laser*. Every apparatus that can be produced as a source or amplifier of a coherent electromagnetic radiation in the 180 nm-1 nm wavelength interval usually by the stimulated emission phenomenon.
12. *Limit of accessible emission (LEA)*. The maximum level of accessible emission allowed to a particular class.
13. *Maintenance*. The execution of the regulations and procedures specified in the directories provided by the manufacturer to ensure the optimal performance of the apparatus.
14. *Access panel*. The part of the case or of the safety case that allows once it has been removed or moved to access the laser radiation.
15. *Radiating power or radiating flux*. The power emitted, transmitted or received in the form of radiation. The radiating power is expressed by the formula:

$$\Phi = dQ/dt$$

The symbol is Φ or P, the measure is as watt (W).

16. *Radiance*. Parameter defined by the following formula:

$$L = d\Phi/dA \cdot \cos\theta \cdot d\Omega$$

Where $d\Phi$ is the radiating flux transmitted by an elementary beam passing through the given point and propagating in the solid angle $d\Omega$ where the given direction is contained; dA is the area of a section of such a beam containing the given point and θ is the angle between the normal to dA and the direction of the beam. The symbol of the radiance is L, the measure is as ($W \cdot m^{-2} \cdot sr^{-1}$).

17 *Collateral radiation*. Any electromagnetic radiation in the wavelength interval 180 nm-1 nm, except the laser radiation, emitted by a laser apparatus, physically needed for the operating of a laser or as a result of the functioning itself.

18. *Laser radiation*. Any coherent electromagnetic radiation emitted from a laser apparatus with wavelength in the 180 nm-1 nm interval produced by stimulated emission.
19. *Scattered reflection*. The change of the spatial distribution of a radiation beam when it is scattered over several direction from a surface or a medium. A perfect scatterer eliminated any correlation between the directions of the incident and emerging radiations.
20. *Direct vision of the beam*. All view conditions under which the eye is exposed to a laser beam directed or reflexed in a specular way, that are different from wision, for instance, of scattered reflexions.
21. *Controlled laser area*. The area in which the presence and the activity of people are regulated by suitable control procedures and that is under surveillance to protect against the risk of laser radiation.
22. *Nominal eye risk area (ZNRO)*. The area out of which the irradiation or the exposure to the beam energy is higher than the maximun allowed exposure (EMP) for the cornea, including the possibility of a wrong training of the laser.
23. *Extended nominal eye risk area*. The ZNRO comprising the possibility of optically-assisted vision.

2 Responsibility

2.1 Duties of the Head of the Department

The Head of the Department or the Director of the facility, as an executive is in charge with the following duties:

- Permits the access to the ruled areas;
- Designes the Laser Safety Technician (TSL);
- Acquires the suggestions of the TSL, providing him all needed information;
- Exposes the safety indications and the signaling provided for;
- Delimits and indicates the controlled areas, including those that are temporary, and gives rules to gain access to them;
- Prepares the needed prevention and safety measures;
- Takes care that the rules are doserved.

2.2 Duties of the Responsible

The laboratory responsible prepares, in accordance with the Head of the Department and on the basis of the indications provided by the TSL, the prevention and safety measures; in particular, he/she

- Verifies in advance the dangers, reduces as much as possible the use of the lasers together with the number of people working with them;

- Sets up the specific procedures and the individual prevention and safety tools even on the basis of the indications provided by the TSL;
- Carries out the indications and the prescriptions provided by the TSL and by the Safety Service at the installation of the apparatus;
- Takes care so as the trajectory of the beam is at the level of the eyes of the operators as little as possible and sets up the individual protection tools (goggles, etc.);
- Avoids unwanted specular reflexions and evaluates and prevents that the accidental ones may happen;
- Avoids the uncontrolled diffusion of class 4 beams as well as their interaction with flammable materials;
- Verifies that the electric connections and the grounding of the metal parts that could be under tension are correctly predisposed;
- Verifies the presence of possible collateral risks (gas under pressure, cryogens, collateral radiations, etc.), sets up suitable protection measures against those risks and avoids the production of harmful gases, fumes or particulates not properly aspired;
- Takes care that the key switch is removed when the class 3B or 4 laser is not working.

2.3 Operator duties

The operators must:

- Follow the regulations of the present set of rules as well as the prescriptions set up by the Responsible and the TSL;
- Wear the goggles or the masks specific for the source in use and keep them with care;
- Don't watch at the laser beam through optic fibers or collecting systems (telescopes, microscopes, etc.) without expressed authorization of the Responsible; never watch directly at the beam neither when wearing protective goggles;
- Be careful to avoid uncontrolled or accidental reflexions, hence don't wear watches, bracelets, earrings, etc.;
- Be sure that all established safety conditions are correctly set up before directing the beam to an area you cannot observe directly;
- Avoid removing or modifying without being authorized by the responsible, the protection and interlock tools; also avoid performing manoeuvres that are not of your direct competence or such that safety can be compromised;
- Inform the Responsible when prevention and safety tool are out of order or damaged; also inform the Responsible about possible dangers that have come to your knowledge. In these cases, interrupt the use of the laser and eliminate possible immediate dangers;
- Act in order to limit the consequences of possible accidents and inform immediately the Responsible or the Head of the Structure.

2.4 The laser safety technician

Where they are set up:

- Class 3R laser emitting energy at a wavelength out of the 400-700 nm range,
- Class 3B laser
- Class 4 laser,

a laser safety technician must be designed, with specific competences in the laser system field and their optical properties.

2.5 Duties of the TSL

The laser safety technician:

- Gives the permission to install new laser systems giving the relative rules;
- Controls that the rules are followed;
- Controls that the safety measures are adopted;
- Indicates the proper controls that must be performed;
- Provides for the classification of those laser systems whose relative class is unknown or that have undergone such modifications that have changed their class.

3 Risks arising from the use of the laser

3.1 Classification of the laser systems

The laser systems have a large variability in the wavelength of the radiation as well as in its power, in the characteristics of the impulse and in beam geometry. It is not possible to consider the laser as a whole for which common limits and operating conditions are valid.

Therefore, the set of rules introduced a classification specifically referring to the accessible emission of the laser system as well as to the potential danger (for eye and skin exposure) based on its characteristics.

The classification is as follows:

- Class 1: laser that are safe under operating conditions you can reasonably foresee, including vision with optical tools.
- Class 1M: Laser with 302.5 nm $< \lambda >$ 4000 nm that are safe under operating conditions you can reasonably foresee but that can be potentially dangerous when the operator uses optics for beam visualization.
- Class 2: Laser emitting radiations with 400 nm $< \lambda >$ 700 nm for which the protection is guaranteed by the natural body defences, including the palpebral reflex.
- Class 2M: laser emitting radiations with 400 nm $< \lambda >$ 700 nm for which the protection is guaranteed by the natural body defences including the palpebral reflex but whose observation may be more dangerous when the watcher uses optics for beam visualization.
- Class 3R: laser emitting radiations with 302.5nm $< \lambda >$ 10^6 nm in which the direct observation of the beam is potentially dangerous but less than that of the laser of the following class 3B; hence, building and control rules less stringent apply.
- Class 3B: laser that usually are dangerous in case of direct vision of the beam, but whose scattered reflections usually are not dangerous.
- Class 4: laser able to produce scattered reflections that are dangerous; they can produce skin lesions and could represent a fire risk. The use of such apparatus requires extreme caution.

For each laser system the relative class must be known.

The classification is certified by the provider or, in case of prototypes, by the Responsible; for each apparatus the relative class is reported on a tag on the instrument (see Appendix A).

3.1.1 Modifications

When an apparatus previously classified is modified so that any aspect of its performance or functions becomes altered, the Responsible of the laboratory charged with such an apparatus in collaboration with the Laser Safety Technician must reclassify the apparatus providing it with a new tag.

3.2 Side risks

In addition to the intrinsic risks, the use of the laser systems can determine side risks.

3.2.1. Electric risks

Many laser systems employ high tension for their functioning. The pulse lasers may be highly dangerous due the amount of energy stored in their condensers. When not suitably shielded, circuit components such as electronic tubes requiring anode tensions as higher as 5 kV may emit X rays. All electric circuits must therefore be certified by competent technicians.

3.2.2. Chemical risks

Risks arising from any manipulation of chemicals and the relative regulations are treated in the safety provisions of the individual structures of the Pole, you can refer to.

3.2.2. Collateral radiation

The collateral ultraviolet radiation may arise from flash lamps and continuous emission laser discharge tubes particularly when ultraviolet transmission tubes or mirrors such as the quarts ones are used.

The visible and near infra-red radiation emitted from flash tubes and pumping sources as well as the back radiation from the target may have radiance enough to produce potential danger.

The protection from the collateral radiation is ensured by the eye protections used for safety against the laser radiation.

3.2.3. Cryogenic refrigerants

The risks arising from the manipulation of refrigerants liquids and the relative rules are treated in the safety provisions of the individual structures of the Pole, you can refer to.

3.2.4. Atmospheric contamination

During the use of laser systems in a research laboratory it is possible to produce contaminant emissions in the following instances:

- vaporization of targer materials;
- any gas arising from gas discharge laser systems or from the products of the laser-triggered reactions such as bromine, chlorine and cyanidric acid;
- any gas or vapour from cryogenic refrigerants.

All these cases must be evaluated when the system is installed, when the case and following the proposal of ther TSL, the system will be provided with a suitable aspiration device.

3.2.5. Fire risks

High energy class 4 laser radiations can fire objects and/or substances they may interact with. Such risks will be evaluated by the TSL when the system is installed; the TSL, in agreement with the Safety Office of the Pole, will set up all needed anti-fire measures.

4 Prevention and safety measures

4.1 Training and information

Anyone operating with class 1M through 4 laser systems must have received in advance a suitable training; the latter will comprise at least:

1. the laser classification criteria;
2. the risks arising from the use of the lasers with reference to the class they belong to;
3. the confidence with the system operating procedures;
4. the proper use of the danger control procedures, of the warning signals, etc.
5. the necessity of personal protection;
6. the report procedures in case of accident;
7. the biological effects of the laser to eyes and skin;
8. the possible medical controls.

The responsible of the laboratory must provide all operators with a copy of this set of rules.
Similarly, the operators will be provided with the operational protocols of the individual laser systems prepared by the Responsibles with the aid of the TSL.
The Safety Service of the Pole, together with the TSL and the Directors of the Structures will prepare systems to evaluate the training levels.

4.2 Individual safety tools

4.2.1. Eye protection

In the areas at risk where are in use

- Class 3R laser apparatuses emitting energy with wavelengths out of the 400-700 nm range,
- Class 3B laser apparatuses,
- Class 4 laser apparatuses

the operators must wear eye protection adequate for the specific wavelengths.

To this purpose, the TSL locates and delimits the areas we are referred to and establish the protection tools to be worn inside those areas.

The eye protections are an individual protection tool (DPI) and must follow the CE rules in this matter (UNI EN 207 and UNI EN 208)

Avoiding any protections wearing is possible when:

a) the technical and behavioural procedures are such that the potential risk of exposure exceeding the applicable EMP is eliminated;
b) the unusual operational prescriptions make it impossible to use eye protections.

Such exceptional operational procedures must be undertaken by the Responsible of the system exclusively with the approval of the TSL.

4.2.2 Protective dresses

If an exposure exceeding the EMP for skin is possible, the TSL will evaluate the opportunity to prescribe the operators to wear specific protective dresses.

In particular, class 4 laser systems are a potential risk of fire and the eventual protective dresses to be worn must be composed of suitable fire- and thermoresistant material with specific stability and resistance to the laser radiations.

4.2.3. Alignment cards

When the ordinary maintainance requires the alignment of the components along the beam path, such an operation will be performed by using safe tools (alignments cards).

Alignments cards specific for the relative wavelengths must be used.

These tools will be evaluated by the TSL.

4.3 Measures concerning the rooms

4.3.1. Use of and access to the laser systems

The use of class 1 M, 2M, 3R, 3B and 4 laser systems, and usually the access to the rooms where they are placed and operate, is reserved to the operators indicated by the Responsible of the laboratory who has the laser system in charge, upon verification by the Responsible, with the aid of the TSL and the Safety Office of the Pole, that each operator is provided with suitable levels of training and information about safety concerning the use of laser systems.

Hence, the Responsible of the laboratory will communicate to the Director of the Structure and to the Safety Service of the Pole the names of the operators allowed to access those rooms.

To access laboratories harbouring class 3B or 4 laser systems, visitors need the permission and supervision of the Responsible. Visitors must be accompanied by a qualified operator who is responsible for their safety.

4.3.2. New installations

To install a new class 1M or class 4 laser system, the authorization by the TSL and the Safety Office of the Pole is needed.

The authorization must take into account the class and type of the apparatus, the characteristics of the room where the latter will be installed, the DNRO and all potential, direct and side risks.

The authorization will be accompanied by the prescriptions and the safety measures (procedures, DPI, etc.) to be adopted by the operators.

The evaluations by the TSL are acknowledged by the Responsible of the laboratory; they will constitute an operational protocol of the laser system to be kept at disposition of the operators in the room where the system is installed.

4.3.3 Substantial modifications

To substantially modified laser systems the same measures will apply as those for new apparatuses.

4.3.4 Controlled laser area

For the installation of class 1M through 4 lasers a controlled area must be defined to which the only authorized people is allowed to access on the basis of the prescriptions set up by the TSL and the Safety Office.

Usually the controlled area usually is the room where the laser system is installed; anyway, its dimensions cannot be less than those of the ZNRO.

In special cases, the controlled area may have smaller dimensions than those of the room where the laser system is hosted (anyway, these will not be lesser than those of the ZNRP); in such cases, the controlled ares will be delimited by suitable protective barriers, under the direction of the TSL.

The radiation out of the ZLC cannot be higher than that of class 1 systems.

4.3.5. Warning signals

The accesses to the controlled ares must hold warning signals containing risk advices together with the symbols prescribed by the technical provisions.

4.4 Measures concerning the apparatuses

4.4.1 Maintainance, repair or modification operations

The maintainance, repair or modification operations can be performed only by operators that are qualified for the specific task and authorized by the Responsible.

Any beam alignement involving the opening of the case and the coupling of optical fibers for data transmission must be performed under the supervision of the responsibles of the apparatus.

4.4.2 Switching off operations

When it is not operating, as a rule the laser must be disabilited so as to prevent any unauthorized use.
The class 3B o 4 lasers must be equipped with key switches. The keys must be removed when the laser is not operating so as to avoid any unauthorized use. Alternatively, the room where the apparatus is harboured will be locked.
Laser harbouring rooms will be cleaned only when the apparatuses are off.

4.4.3. Remote block connector

Class 4 lasers and, possibly, also class 3B lasers, must be equipped with panic botton easily accessible from the operator place.
In the research laboratories the connector must be connected to an emergency block at less than 5 meters from the operation area.

4.4.4. Labelling

All lasers must be provided with suitable tags reporting the laser class and signaling the openings from which the radiation emerges. The appendix reports the specific phrasing and prescriptions.

4.4.5. Panic bottons

Where protective cases are present hindering the access the a class 3R, 3B or 4 radiation, panic bottons are required for radiation extintion in case of accidental opening of the case. These tools can be disactivated only for specific maintainance operations and under explicit authorization of the Responsible, who will also verify their correct reactivation at the end of the maintanance operations.

4.4.6. Observation optics

All collection optics (such as lenses, telescopes, microscopes, endoscopes, etc.) aimed at observing with the use of lasers or laser systems must harbour suitable safety tools (such as panic bottons, filters, attenuators, etc.) automatically activated to maintain at safety levels the laser radiation through the collecting optics and, when possible, the correct EMP, in all operational and maintainance conditions. Different conditions must be authorized in advance by the TSL.

4.4.7. Placing of the controls

The controls must be placed so as when the regulations are performed the exposure will not be higher than the values for class 1 and 2 LEA.

4.4.8. Prototype sources

The prototype sources are sources under investigation not yet characterized.

The prototype sources can be used without panic bottons, the authomatic sound and light signals and labellings. Such sources must be confined into suitable laboratories. Their use is allowed only to operators specifically authorized by the Director of the structure and suitably trained by the Responsible of the laboratory. The use of such sources will strictly follow the preventive presciptions of the TSL. The Safety Service of the Pole must be informed about the esistence of a laboratory for prototypes.

4.4.9. Data transmission

The access to the rooms where optical fibers for data transmission with class over 3A lasers converge must be severely regulated. The personnel must avoid watching directly the operating fiber terminals or the open connectors and use suitable tools for eye protection or visors for indirect vision (IR converters, etc.). The optical fiber system management must be assigned to a Responsible, who must activate and held operative a risk control program with the advice of the TSL.

4.5 Beam concerning measures

4.5.1. Beam termination

To avoid any unwanted exposure to a class 3B or 4 laser radiation or the production of accidental reflexions the beams should be terminated on a stopping medium or attenuation at the end of the usable working area.

The TSL establishes the behaviour of the operators in such cases.

The material the stopping medium is made of must have scattering properties and be endowed with suitable reflecting, thermal or absorption properties.

4.5.2. Beam trajectories

The exposed laser beam trajectories when possible should be over or under the eye level.

The beam trajectories of

- Class 3R laser apparatuses emitting at a wavelength out of the 400-700 nm range,
- Class 3B or 4 laser apparatuses

should

- be as much as possible short,
- have as few as possible changes of direction,
- avoid to cross the passing of persons and other approaches.

The laser beams should, when possible, be closed into a safety case (for instance a tube).

The beam case (for instance a tube) should be firmly fixed but preferably it should not be connected to the beam producing components.
The beam must not involve doors, windows, passages and working places; the beam must be confined by suitable barriers.

4.5.3. Specular reflexions

Mirrors, lenses and beam splitters should be firmly fixed and undergo only controlled motions.

Special care is required in the choice of the optical components for Class 3B and Class 4 lasers and in the cleaning of their surfaces.

Attention must be given to prevent any accidental specular reflexion of radiations from Class 1M and 2M lasers by surfaces able to focalize the beam.

Keep in mind that:

- Surfaces that seem to reflect the radiation in a scattered way may, in effect, reflect a significant fraction of that in a specular way, particularly in the infra-red region.

- Such an effect may be dangerous especially at distances higher that those expected for purely diffusive reflections.
- potentially dangerous specular reflections are produced by all surfaces of the transmissive optical components such as lenses, prisms, slits and bean splitters.
- The potentially dangerous radiation may also be transmitted through reflecting optical components such as the mirrors (for instance, the infra-red radiation passing through a visible radiation reflector).

5 Medical surveillance

5.1 Clinical tests

The personnel operating with Class 3B and Class 4 lasers is monitored by eye tests; such tests are endowed only with medicinal law value and are not necessarily part of the safety program.

Immediately after an evident or suspected dangerous eye exposure, a medical test performed by a qualified specialist must be done. A complete biophysical analysis of the circumstances of the accident should accompany such a test.

6 Tags

6.1 Overview

Any laser apparatus must be provided with one or more tags. The latter must be:

- firmly and permanently fixed,
- readable,
- clearly visible during the operation, maintainance or technical assistance of the apparatus,
- positioned so as they can be read without any exposure the the laser beam exceeding the LEAs for Class 1 apparatuses.

The tag text, edges and symbols must be in black on a yellow background, excep those for Class 1 apparatuses.

When the size or the building characteristics of the apparatus make it impossible to provide it with tags, the latter must be reproduced in the body of the information for users or printed on the package.

Two types of tags are used: information tags and warning tags. The former provide the information relative to the class of the laser and other informative phrasing about the specifications and the risks; the latter warn about the danger due to the presence of the laser apparatus.

The tag sizes must follow well defined proportions.

With the exception of the Class 1 apparatuses, the information tag of every laser apparatus must indicate:

- the maximum power of the emitted laser radiations,
- the length of the pulse time (when the case)
- the emitted wavelength(s)

the name and the date of publication of the set of rules by which the apparatus has been classified must be indicated on the information tag or in any other place of the apparatus close to the tag.
For Class 1 and Class 2 apparatuses, the indications may be included into the operating instructions instead than being reported on specific tags.

6.2 Information tags

Figure 1 outlines an information tag and specifies the relative proportions; the dimensional ratios between the specific sizes of the information tags are reported in Table 1.7.

Figure 1 - information Tag

The relationship between the maximum distance at which the tag may still be read and the minimum surface of the tag is the following:

$$A = L^2/2000$$

Where A and L are expressed in meters and $L < 50$.

Tab. P. 14 Minimal heigth of the phrasing
The size of the text must be such that it can be read.
The g1 dimension is recommended

Table 1 proportions between the information tag sizes.

6.3 Warning tags

Figure 1 shows a warning tag with the characteristic proportions. Table 1 reports the dimensional ratios between the characteristic parts of the warning tags.

Figure 2 warning tag.

Tab p. 15 The D_1, D_2, D_3, g and d dimensions are recommended values

Table 2 Dimensional ratios of the warning tags.

The relationship between the maximal distance at which the tag may still be understood and the minimal surface of the tag is the following:

$$A = L^2/2000$$

Where A and L are expressed in meters and $L < 50$.

6.4 Phrasing of the information and warning tags

Hereafter the phrasing in the tags for the apparatuses of each class is reported.

6.4.1. Class 1

On each class 1 apparatus an information tag must be placed with the expression:

6.4.2. Class 1M

On each class 2M apparatus an information tag must be placed with the expression:

After the words "STRUMENTI OTTICI" it is possible to add a word such as "BINOCOLI o TELESCOPI" or "LENTI DI INGRANDIMENTO" depending on the type of beam collecting tool for which the apparatus has been classified class 1M.

6.4.3. Class 2

On each class 2 apparatus an information tag must be placed with the expression:

A warning tag must also be placed on the apparatus.

6.4.4. Class 2M

On each class 2M apparatus an information tag and a warning tag must be placed with the expression:

After the words "STRUMENTI OTTICI" it is possible to add a word such as "BINOCOLI O TELESCOPI" or "LENTI DI INGRANDIMENTO".

6.4.5. Class 3R

Class 3R lasers are distinguished on the basis of the wavelength range. When the wavelength is in the 400 nm-1400 nm range an information tag and a warning tag must be placed with the expression:

For wavelengths under 400 nm or above 1400 nm, an information tag and a warning tag ,must be placed with the expression:

Furthermore, close to every opening from which a laser radiation above class 1 and 2 is emitted, a tag must be placed with the expression:

APERTURA LASER

or

6.4.6. Class 3B

Each class 3B laser must carry an information tag and a warning tag with the expression:

Furthermore, close to every opening from which a laser radiation above class 1 and 2 is emitted, a tag must be placed with the expression:

APERTURA LASER

or

6.4.7. Class 4

Each class 4 laser must carry an information tag and a warning tag with the expression:

Furthermore, close to every opening from which a laser radiation above class 1 and 2 is emitted, a tag must be placed with the expression:

APERTURA LASER

or

6.5 Access panel tags

Each connection, safety repair panel and safety case panel that, once removed or moved, allows humans to access a radiation higher than class 1 radiation, must carry a tag with the words:

Followed by the indications relative to the class of radiation to which one can be exposed when the case is opened, as reported hereafter.

6.5.1. Accessible radiation under class 1M

If the accessible radiation is under the class 1M LEA, the following expression must be reported:

6.5.2. Accessible radiation under class 2

If the accessible radiation is under the class 2 LEA, the following expression must be reported:

6.5.3. Accessible radiation under class 2M

If the accessible radiation is under the class 2M LEA, the following expression must be reported:

6.5.4. Accessible radiation under class 3R

If the accessible radiation is under the class 3R LEA and the wavelength is in the 400-1400 nm range, the following expression must be reported:

If the accessible radiation is under the class 3R LEA and the wavelength is under 400 nm or above 1400 nm, the following expression must be reported:

6.5.5. Accessible radiation under class 3B

If the accessible radiation is under the class 3B LEA, the following expression must be reported:

6.5.6. Accessible radiation above class 3B

If the accessible radiation is above the class 3B LEA (and hence has class 4 features), the following expression must be reported:

Tags for panels with safety block
If panels are endowed with safety block, at the end of the relative expression the following expression must be added: E DI GUASTO O DISATTIVAZIONE DEI BLOCCHI

6.5.7. Panels with safety block

Suitable tags must be associated to safety blocks that can be excluded thus allowing the access of the operator to radiations above class 1; these tags must be visible before and after the exclusion of the block and must be located as much close as possible to the opening produced by the block exclusion.

The tags must report the expressions for the access panels with added the following words:

E DI GUASTO O DISATTIVAZIONE DEI BLOCCHI

6.5.8. Warning for visibile or invisibile radiations

When the expression on the tag holds also the words “radiazione laser”, it is possible to specify if the radiation is visible or invisible.

In case of invisible laser radiation, it is possible to write “radiazione laser invisibile”. When both visible and invisible radiations are present, it is possible to write “radiazione laser visibile e invisibile”. When only visible radiation is present, the expression “radiazione laser” may be changed with the expression “luce laser”.

For LED radiation, the word “laser” may be changed with the word “LED”.