	INSTRUCTION DE SÉCURITÉ SAFETY INSTRUCTION	IS 22 Rev.
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**RULES FOR THE
SAFE USE OF LASERS
AT CERN**

**REGLES DE SECURITE POUR
L'UTILISATION DES LASERS
AU CERN**

This replaces the Instruction 22 issued in August 1982

Rules for the safe use of lasers at CERN

1 GENERAL

This Safety Instruction is published by the TIS Commission under the procedure set out in the CERN Safety Policy document SAPOCO/42 and in application of the CERN Staff Rules and Regulations.

2 SCOPE

The radiation produced by lasers may be hazardous to the human eye and skin. It may also present a fire and/or explosion risk. Other hazards may exist in conjunction with the use of lasers. This Safety Instruction defines rules to limit the dangers resulting from the operation of lasers.

3 CLASSIFICATION OF LASERS AND EXPOSURE LIMITS

Limits for laser exposure at CERN are as defined by the International Radiation Protection Association [refs. 1, 2] for:

- a) direct ocular exposure,
- b) exposure of the skin,
- c) viewing of an extended-source laser or a laser beam by diffuse reflection [ref. 1].

These limits are applied in many countries including France and Switzerland.

Lasers and laser products are classified according to their exposure hazards. The following classification based on the recommendation of the International Electrotechnical Commission [ref. 3] applies at CERN:

Class and Description	Reason for Classification
Class 1	The output power is so low that they are inherently safe.
Class 2 Low power, low risk Visible C.W. and pulsed lasers	In the case of C.W. lasers, some protection is afforded by natural aversion response of the eye (blink reflex). Hazard can be controlled by relatively simple procedures.
Class 3A Medium power lasers	Some protection still provided by blink reflex, but direct intra-beam viewing with optical aids is hazardous.
Class 3 B	Hazard from direct beam viewing and from specular reflections. More detailed control measures are necessary.
Class 4 High-power lasers	Not only hazard from direct beam viewing and from specular reflections, but viewing of diffuse reflections can also be hazardous. Their use requires extreme caution.

The classification is made according to the Accessible Emission Limit (AEL). The AEL for a given classification is the maximum accessible emission level permitted within a particular class computable as a function of emission duration, and time and wave-length dependent factors. AEL values are given in ref. [3].

Means of measuring the class limits and the determination of accessibility are given in ref. [4]. In case no information is supplied by the manufacturer, the TIS Radiation Protection Group will determine the class of a laser following the AEL tables presented in ref. [3]. These limits are put into perspective for C.W. lasers, assuming a potential exposure duration of a full day, in Figure 1.

The precautions related to specific classes of lasers are given in *Appendix 1* [5].

Figure 1

Accessible emission limits for C.W. lasers
assuming a potential exposure duration of a full day (from ref. 4).

4 GENERAL CONDITIONS FOR USE

All lasers brought onto the CERN site shall be registered with TIS Commission (RP Group), who will evaluate the hazards involved and recommend the safety precautions to be taken.

Before starting to use lasers on the CERN site, the persons concerned may be asked to undergo an eye examination to be arranged by the Medical Service. This examination may be repeated periodically. The Medical Service shall be contacted immediately after any accidental exposure to a laser beam.

For each laser installation, a responsible user shall be registered with TIS/RP to be instructed on the safe use of such installations. The registered user shall make sure that all safety precautions are taken in the area where the laser is used.

All lasers shall bear warning labels and notices in accordance with their class, as defined in *Appendix 2*.

No laser system shall be put into operation before TIS Commission has inspected the installation and area concerned. TIS Commission will provide guidelines for planning and operation of lasers of all classes except Class 1. TIS Commission will organize inspections annually and whenever the installation has been modified.

References

- 1 International Radiation Protection Association (IRPA). Guidelines on limits of exposure to laser radiation of wavelengths between 180 nm and 1 mm, Health Physics Vol. 49, N°2, pp 341-359 (1985)
- 2 International Radiation Protection Association (IRPA). Recommendations for minor updates to the IRPA 1985 Guidelines on limits of exposure to laser radiation, Health Physics Vol. 54, N°5, pp 573-574 (1988)
- 3 International Electrotechnical Commission (IEC). Radiation safety of laser products, equipment classification requirements and user's guide, IEC standard publication 825 (1984)
- 4 D. Sliney and M. Wolbarsht, Safety with Lasers and Other Optical Sources, Plenum Press, New York (1980)
- 5 Safety in Universities, Notes of Guidance, Part 2:1 Lasers, Ass. of Commonwealth Universities for the Committee of Vice-Chancellors and Principals, London (1978).

Precautions related to specific classes of lasers (from ref. 5)

1 Use of Class 1 Lasers

A register must be kept of all such lasers, which must be labelled in accordance with the details given in Appendix 2.

2 Use of Class 2 and Class 3A Lasers

A register must be kept of all such lasers, which must be labelled in accordance with the details given in Appendix 2.

Precautions must be adopted to prevent continuous viewing of the direct beam and, in the case of Class 3A lasers, to control the use of optical viewing aids such as microscopes, binoculars, etc., so that the exposure limits are not exceeded.

3 Use of Class 3B and Class 4 Lasers

A register must be kept of all such lasers, which must be labelled in accordance with the details given in Appendix 2.

Class 3B lasers present a hazard to the eye if the direct beam or specular reflections are viewed without the protection afforded by features of the design or by suitable goggles.

Class 4 lasers present an even greater hazard to the eye and, in addition, the viewing of diffuse reflections can also be hazardous. This class of lasers can be a hazard to the skin and can also constitute a serious fire hazard. It must be recognised that this class embraces all lasers with power outputs in excess of 0.5 watt. Now that lasers with outputs of terawatts are available, this is a very wide range indeed, and it is clear that, for safety considerations, not all lasers in this class can be treated alike.

The actual precautions needed for each Class 3B or Class 4 laser installation shall be carefully planned in advance by TIS Commission in conjunction with the Divisional Safety Officer concerned. Nevertheless, lasers of either of these classes shall only be used in laboratories or other clearly defined areas which can be set aside for this purpose and where the hazards can be effectively controlled. These will be called "Designated Laser Areas".

Designated Laser Areas must be clearly identified. The sign shown in Figure 2 of Appendix 2 must be used for this purpose and must be incorporated in a suitable notice or panel which must be displayed at the entrance to each Designated Laser Area.

Note:

Warning notices, especially at entrances to rooms, must be in place when the hazard exists in fact and taken away when it does not exist. Consideration should also be given to the provision of a suitable visual signal sited at the entrance to the area and interlocked with the laser, so that it functions whenever the laser is being operated.

Entry to a Designated Laser Area shall be limited to authorized personnel only when the laser is in operation.

In special cases, for instance when high-power pulsed lasers are used, an interlock on the door leading into the area should be provided to prevent entry when the laser is in use.

The Designated Laser Area must be constructed and equipped in order to minimise the risk to authorised persons working in the area, both from the laser itself and from associated electrical, mechanical, chemical and other hazards. It must also provide protection to people outside the area.

Each Class 3A, Class 3B and Class 4 laser product shall incorporate a key-operated master control. The key shall be removable and the laser shall not be operable when the key is removed. In this context, the term "key" includes any other control devices, such as magnetic cards, cipher combinations, etc., which serve the same purpose.

Each Designated Laser Area should be purpose-designed for the particular laser application. Apart from the points already mentioned, some of the more important aspects which must be considered are discussed in refs [3, 4].

4 Use of embedded laser products

A register must be kept of all such lasers, which must be labelled in accordance with the details given in Appendix 2.

An embedded laser product is one which, because of engineering features limiting the accessible emissions, has been assigned a class number lower than the inherent capability of the laser incorporated.

The design of the system must be such that the laser(s) can be used in complete safety with regard to allied hazards, and the enclosure must be such that it is not possible for personnel to gain access during normal operations.

With respect to their protective housing, any parts of embedded laser products that can be removed or displaced for servicing and which would allow access to laser radiation in excess of the AEL assigned and are not interlocked shall be secured in such a way that removal or displacement of the parts requires the use of tools.

Access panels of protective housings intended to be removed or displaced during maintenance or operation, thereby allowing human access to laser radiation from the embedded laser in excess of the AEL of Class 1 or Class 2 and the AEL of the class assigned, shall be provided with a safety interlock. The safety interlock shall be of a design which prevents the removal of the panel until the accessible emission values are below the AEL for the class assigned and inadvertent resetting of the interlock shall not in itself restore emission values above the AEL of the class assigned.

If a deliberate override mechanism is provided, the manufacturer shall also provide adequate instructions about safe methods of working. It shall not be possible to leave the override in operation when the access panel is returned to its normal position. The interlock shall be clearly associated with a label conforming to Appendix 2. Use of the override shall give rise to a distinct visible or audible warning whenever the laser is energized or capacitor banks are not fully discharged, whether or not the access panel is removed or displaced. The visible warnings shall be clearly perceptible through protective eyewear specifically designed or specified for the wavelength(s) of the accessible laser radiation.

An emergency stop for the whole of the system must be provided. It must be clearly labelled and sited in a conspicuous and convenient position.

Warning Labels and Notices

1 General

All lasers and laser systems must bear labels, giving details of their maximum output power(s), of the wavelength(s) concerned, whether they are C.W. or pulsed and, in the latter case, details of pulse duration and repetition frequency. In addition, each specific class of laser must be labelled in accordance with the details given in Sections 2 to 7 below. In this regard, it must be noted that, if the laser output is outside the wavelength range of 400-700 nm, the explanatory label must be modified to read "Visible and Invisible Laser Radiation".

It is important that all labels be of a permanent nature and be legible and clearly visible during operation, maintenance or service of the laser. They must be positioned in places where they can be read without access to laser radiation.

2 Labelling of Class 1 Lasers

A yellow explanatory label, with the dimensions indicated in Figure 1, must be fixed to each Class 1 laser, with the wording

Class 1 Laser	Laser classe 1
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3 Labelling of Class 2 Lasers

A yellow explanatory label, with the dimensions indicated in Figure 1, must be fixed to each Class 2 Laser, together with a hazard label as per Figure 2. The explanatory label must display the wording:

Laser Radiation Do not look into the beam Class 2 Laser	Rayonnement laser Ne pas regarder dans l'axe du faisceau Laser classe 2
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4 Labelling of Class 3A Lasers

A yellow explanatory label, with the dimensions indicated in Figure 1, must be fixed to each Class 3A laser, together with a hazard label as per Figure 2. The explanatory label must display the wording:

Laser Radiation Do not look into the beam or view directly with optical instruments Class 3A Laser	Rayonnement laser Ne pas regarder dans l'axe du faisceau directement ou avec des instruments d'optique Laser classe 3A
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5 Labelling of Class 3B Lasers

A yellow explanatory label, with the dimensions indicated in Figure 1, must be fixed to each 3B laser, together with a hazard label as per Figure 2. The explanatory label must display the wording:

DANGER Laser Radiation Avoid exposure to the beam Class 3B Laser	DANGER Rayonnement laser Eviter l'exposition au faisceau Laser classe 3B
---	---

In addition, a label must be fixed close to the laser output aperture(s), bearing the words "**Laser Output**".

6 Labelling of Class 4 Lasers

A yellow explanatory label, with the dimensions indicated in Figure 1, must be fixed to each Class 4 laser, together with a hazard label as per Figure 2. The explanatory label must display the wording:

DANGER Laser Radiation Avoid eye or skin exposure to direct or scattered radiation Class 4 Laser	DANGER Rayonnement laser Eviter l'exposition des yeux ou de la peau aux rayonnements directs ou diffus. Laser classe 4
---	---

In addition, a label must be fixed close to the laser output aperture(s) bearing the words "**Laser Output**".

7 Labelling of Access Panels

Any section of the laser system enclosure which, when removed, permits exposure to laser radiation in excess of the AEL for Class 1 must have fixed to it a label with the words:

Caution - Laser Radiation when open	Attention - Rayonnement laser en cas d'ouverture
--	---

and with the additional wording as follows, depending on the accessible radiation:

Do not look into the beam	Ne pas regarder dans l'axe du faisceau
----------------------------------	---

if the accessible radiation does not exceed the AEL for Class 2

Do not look into the beam or view directly with optical instruments	Ne pas regarder dans l'axe du faisceau directement ou avec des instruments d'optique
--	---

if the accessible radiation does not exceed the AEL for Class 3A

Avoid exposure to the beam	Eviter l'exposition au faisceau
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if the accessible radiation does not exceed the AEL for Class 3B

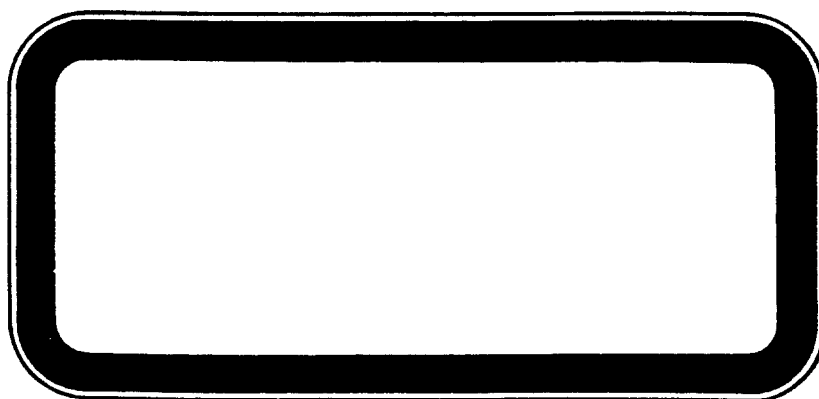
Avoid eye or skin exposure to direct or scattered radiation	Eviter l'exposition des yeux ou de la peau aux rayonnements directs ou diffus
--	--

if the accessible radiation exceeds the limits for Class 3B at any wavelength.

Figure 1

Outline of the label to be used for the identification of the various classes of lasers.

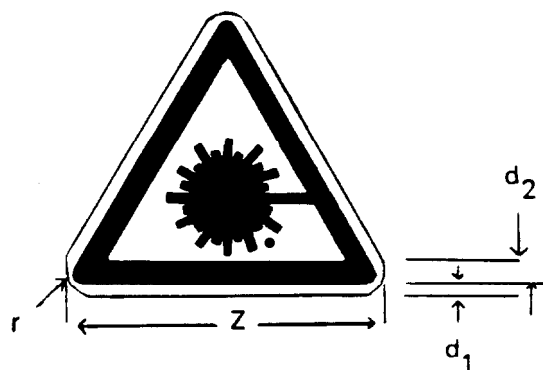
Legend and border: **black** Background: **yellow**
 Details of the legends to be used are given in the preceding part of this appendix.



Dimensions to be determined by the requirements of the particular application. The wording must be large enough to be clearly legible under all circumstances.

Figure 2

Warning label - Hazard symbol
 Symbol and border: **black**
 Background: **yellow**



Dimensions given in mm:

Z	d ₁	d ₂	r
50	1	3	2.5
100	2	6	5
200	4	12	10
400	8	24	20
630	12	36	30

Precautions related to specific classes of lasers (from ref. 5)

1 Use of Class 1 Lasers

A register must be kept of all such lasers, which must be labelled in accordance with the details given in Appendix 2.

2 Use of Class 2 and Class 3A Lasers

A register must be kept of all such lasers, which must be labelled in accordance with the details given in Appendix 2.

Precautions must be adopted to prevent continuous viewing of the direct beam and, in the case of Class 3A lasers, to control the use of optical viewing aids such as microscopes, binoculars, etc., so that the exposure limits are not exceeded.

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The actual precautions needed for each Class 3B or Class 4 laser installation shall be carefully planned in advance by TIS Commission in conjunction with the Divisional Safety Officer concerned. Nevertheless, lasers of either of these classes shall only be used in laboratories or other clearly defined areas which can be set aside for this purpose and where the hazards can be effectively controlled. These will be called "Designated Laser Areas".

Designated Laser Areas must be clearly identified. The sign shown in Figure 2 of Appendix 2 must be used for this purpose and must be incorporated in a suitable notice or panel which must be displayed at the entrance to each Designated Laser Area.

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Warning notices, especially at entrances to rooms, must be in place when the hazard exists in fact and taken away when it does not exist. Consideration should also be given to the provision of a suitable visual signal sited at the entrance to the area and interlocked with the laser, so that it functions whenever the laser is being operated.

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Access panels of protective housings intended to be removed or displaced during maintenance or operation, thereby allowing human access to laser radiation from the embedded laser in excess of the AEL of Class 1 or Class 2 and the AEL of the class assigned, shall be provided with a safety interlock. The safety interlock shall be of a design which prevents the removal of the panel until the accessible emission values are below the AEL for the class assigned and inadvertent resetting of the interlock shall not in itself restore emission values above the AEL of the class assigned.

If a deliberate override mechanism is provided, the manufacturer shall also provide adequate instructions about safe methods of working. It shall not be possible to leave the override in operation when the access panel is returned to its normal position. The interlock shall be clearly associated with a label conforming to Appendix 2. Use of the override shall give rise to a distinct visible or audible warning whenever the laser is energized or capacitor banks are not fully discharged, whether or not the access panel is removed or displaced. The visible warnings shall be clearly perceptible through protective eyewear specifically designed or specified for the wavelength(s) of the accessible laser radiation.

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It is important that all labels be of a permanent nature and be legible and clearly visible during operation, maintenance or service of the laser. They must be positioned in places where they can be read without access to laser radiation.

2 Labelling of Class 1 Lasers

A yellow explanatory label, with the dimensions indicated in Figure 1, must be fixed to each Class 1 laser, with the wording

Class 1 Laser	Laser classe 1
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3 Labelling of Class 2 Lasers

A yellow explanatory label, with the dimensions indicated in Figure 1, must be fixed to each Class 2 Laser, together with a hazard label as per Figure 2. The explanatory label must display the wording:

Laser Radiation Do not look into beam Class 2 Laser	Rayonnement laser Ne pas regarder dans l'axe du faisceau Laser classe 2
--	--

4 Labelling of Class 3A Lasers

A yellow explanatory label, with the dimensions indicated in Figure 1, must be fixed to each Class 3A laser, together with a hazard label as per Figure 2. The explanatory label must display the wording:

Laser Radiation Do not look into beam or view directly with optical instruments Class 3A Laser	Rayonnement laser Ne pas regarder dans l'axe du faisceau directement ou avec des instruments d'optique Laser classe 3A
---	---

5 Labelling of Class 3B Lasers

A yellow explanatory label, with the dimensions indicated in Figure 1, must be fixed to each 3B laser, together with a hazard label as per Figure 2. The explanatory label must display the wording:

DANGER Laser Radiation Avoid exposure to beam Class 3B Laser	DANGER Rayonnement laser Eviter l'exposition au faisceau Laser classe 3B
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In addition, a label must be fixed close to the laser output aperture(s), bearing the words "Laser Output".

6 Labelling of Class 4 Lasers

A yellow explanatory label, with the dimensions indicated in Figure 1, must be fixed to each Class 4 laser, together with a hazard label as per Figure 2. The explanatory label must display the wording:

DANGER Laser Radiation Avoid eye or skin exposure to direct or scattered radiation Class 4 Laser	DANGER Rayonnement laser Eviter l'exposition des yeux ou de la peau aux rayonnements directs ou diffus. Laser classe 4
---	---

In addition, a label must be fixed close to the laser output aperture(s) bearing the words "Laser Output".

7 Labelling of Access Panels

Any section of the laser system enclosure which, when removed, permits exposure to laser radiation in excess of the AEL for Class 1 must have fixed to it a label with the words:

Caution - Laser Radiation when open	Attention - Rayonnement laser en cas d'ouverture
--	---

and with the additional wording as follows, depending on the accessible radiation:

Do not look into beam	Ne pas regarder dans l'axe du faisceau
------------------------------	---

if the accessible radiation does not exceed the AEL for Class 2

Do not look into beam or view directly with optical instruments	Ne pas regarder dans l'axe du faisceau directement ou avec des instruments d'optique
--	---

if the accessible radiation does not exceed the AEL for Class 3A

Avoid exposure to beam	Eviter l'exposition au faisceau
-------------------------------	--

if the accessible radiation does not exceed the AEL for Class 3B

Avoid eye or skin exposure to direct or scattered radiation	Eviter l'exposition des yeux ou de la peau aux rayonnements directs ou diffus
--	--

if the accessible radiation exceeds the limits for Class 3B at any wavelength.

Figure 1

Outline of the label to be used for the identification of the various classes of lasers.

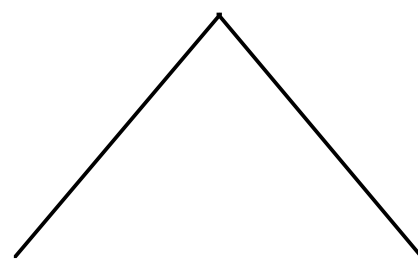
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Warning label - Hazard symbol
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Dimensions given in mm:

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