BRITISH STANDARD

BS EN 207:1999
Incorporating Amendment No. 1 and Corrigendum No. 1

Personal eye-protection — Filters and eye-protectors against laser radiation (laser eye-protectors)

The European Standard EN 207:1998, with the incorporation of amendment A1:2002, has the status of a British Standard

ICS 13.340.20

BSI British Standards

National foreword

This British Standard is the official English language version of EN 207:1998, including amendment A1:2002 and Corrigendum September 2004. It supersedes BS EN 207:1994 which is withdrawn.

NOTE The poor quality of Figure A.1 was noticed when the English language version of amendment A1:2002 to EN 207:1998 was incorporated into the national standard. The error has been reported to CEN in a proposal to amend the figure supplied in amendment A1:2002 to the European Standard.

The start and finish of text introduced or altered by amendment is indicated in the text by tags ▌A1⟩ ⟨A1▐. Tags indicating changes to CEN text carry the number of the CEN amendment. For example, text altered by CEN amendment A1 is indicated by ▌A1⟩ ⟨A1▐.

The UK participation in its preparation was entrusted by Technical Committee PH/2, Eye protection, to Subcommittee PH/2/3, Eye protection against lasers, which has the responsibility to:

— aid enquirers to understand the text;

— present to the responsible European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;

— monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this subcommittee can be obtained on request to its secretary.

Cross-references

The British Standards which implement international or European publications referred to in this document may be found in the *BSI Catalogue* under the section entitled "International Standards Correspondence Index", or by using the "Search" facility of the *BSI Electronic Catalogue* or of British Standards Olnine.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, the EN title page, pages 2 to 17 and a back cover.

The BSI copyright notice displayed in this document indicates when the document was last issued.

This British Standard, having been prepared under the direction of the Health and Environment Sector Committee, was published under the authority of the Standards Committee and comes into effect on
15 March 1999

Amendments issued since publication

Amd. No.	Date	Comments
14119	31 January 2003	See national foreword
15399 Corrigendum No. 1	27 October 2004	Replacement of Table B.2

ISBN 0 580 30718 2

EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

EN 207

September 1998

+ A1

August 2002

ICS 13.340.20

Incorporating corrigendum September 2004
Supersedes EN 207:1993

Descriptors: accident prevention, eyes, safety devices, filters, safety, radiation protection, laser radiation, specifications, transmittance, maximale value, tests, stability, marking, technical notices

English version

Personal eye-protection — Filters and eye-protectors against laser radiation (laser eye-protection)

(includes amendment A1:2002)

Protection individuelle de l'oeil —
Filtres et protecteurs de l'oeil contre les rayonnements laser (lunettes de protection laser)
(inclut l'amendement A1:2002)

Persönlicher Augenschutz —
Filter und Augenschutzgeräte gegen Laserstrahlung (Laserschutzbrillen)
(enthält Änderung A1:2002)

This European Standard was approved by CEN on 24 August 1998. Amendment A1 was approved by CEN on 30 May 2002.

CEN

European Committee for Standardization
Comité Européen de Normalisation
Europäisches Komitee für Normung

Central Secretariat: rue de Stassart 36, B-1050 Brussels

Ref. No. EN 207:1998 + A1:2002 E

Foreword

This European Standard has been prepared by Technical Committee CEN/TC 85, Eye protective equipment, the Secretariat of which is held by AFNOR.

This European Standard supersedes EN 207:1993.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by March 1999, and conflicting national standards shall be withdrawn at the latest by March 1999.

This European Standard has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive(s).

For relationship with EU Directive(s), see informative Annex ZA, which is an integral part of this standard.

Annex A, Annex B and Annex ZA are informative.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

Foreword to amendment A1

This amendment EN 207:1998/A1:2002 to the EN 207:1998 has been prepared by Technical Committee CEN/TC 85, Eye protective equipment, the Secretariat of which is held by AFNOR.

This amendment to the European Standard EN 207:1998 shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by February 2003, and conflicting national standards shall be withdrawn at the latest by February 2003.

This amendment to the European Standard EN 207:1998 has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive(s).

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Malta, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

Contents

1 Scope

This European Standard applies to eye-protectors used for protection against laser radiation as defined in EN 60825-1:1994 [i.e. LED (light emitting diode) radiation is included] in the spectral range 180 nm (0,18 μm) to 1 000 μm. It defines requirements, test methods and marking. A guide is given in Annex B with regard to selection and use.

EN 208 applies for laser adjustment eye-protectors.

NOTE Before selecting eye-protection according to this standard a risk assessment should be undertaken (see Annex B).

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

EN 166:1995, Personal eye-protection — Specifications.

EN 167:1995, Personal eye-protection — Optical test methods.

EN 168:1995, Personal eye-protection — Non-optical test methods.

EN 208, Personal eye-protection — Eye-protectors for adjustment work on lasers and laser systems (laser adjustment eye-protectors).

EN 60825-1:1994, Safety of laser products — Part 1: Equipment classification, requirements and user's guide.

ISO/CIE 10526:1991, CIE standard colorimetric illuminants.

ISO/CIE 10527:1991, CIE standard colorimetric observers.

3 Requirements

3.1 Spectral transmittance of filters and frames

When tested according to **4.1**, the maximum spectral transmittance for the individual scale numbers which shall not be exceeded at the laser wavelength(s) against which they afford protection shall be as given in Table 1.

3.2 Luminous transmittance of filters

When assessed in accordance with **4.2**, the luminous transmittance of the filter relative to the D65 standard illuminant (see ISO/CIE 10526:1991) shall be at least 20 %, unless it is recommended in the information supplied by the manufacturer to increase accordingly by the intensity of illumination at the relevant workplace.

3.3 Stability of filters and frames to laser radiation

When tested according to **4.3**, the filters and frames shall meet the requirements of **3.1** and shall not lose their protective effect under the influence of laser radiation of the power (E) or energy density (H) given in Table 1 for a period of at least 10 s and for 100 pulses and shall not show any induced transmission (reversible bleaching). No splinters shall come away from the side of the filter facing the eye under the influence of the laser radiation. Any melting or other damage of the surface is not considered negative if the protective effect is still ensured.

A1

Table 1 — Scale numbers (maximum spectral transmittance and stability to laser radiation) of the filters and/or eye-protectors against laser radiations

Scale number	Maximum spectral transmittance at the laser wavelength $\tau(\lambda)$	Power (*E*) and energy (*H*) density for testing the protective effect and stability to laser radiation in the wavelength range								
		180 nm to 315 nm			>315 nm to 1 400 nm			>1 400 nm to 1 000 µm		
		D $\geq 3 \times 10^4$	**I, R** 10^{-9} to 3×10^4	**M** $< 10^{-9}$	**D** $>5 \times 10^{-4}$	**I, R** 10^{-9} to 5×10^{-4}	**M** $<10^{-9}$	**D** >0,1	**I, R** 10^{-9} to 0,1	**M** $<10^{-9}$
		E_D W/m²	$H_{I,R}$ J/m²	E_M W/m²	E_D W/m²	$H_{I,R}$ J/m²	H_M J/m²	E_D W/m²	$H_{I,R}$ J/m²	E_M W/m²
L1	10^{-1}	0,01	3×10^2	3×10^{11}	10^2	0,05	$1{,}5 \times 10^7$	10^4	10^3	10^{12}
L2	10^{-2}	0,1	3×10^3	3×10^{12}	10^3	0,5	$1{,}5 \times 10^8$	10^5	10^4	10^{13}
L3	10^{-3}	1	3×10^4	3×10^{13}	10^4	5	0,15	10^6	10^5	10^{14}
L4	10^{-4}	10	3×10^5	3×10^{14}	10^5	5	1,5	10^7	10^6	10^{15}
L5	10^{-5}	10^2	3×10^6	3×10^{15}	10^6	5×10^2	15	10^8	10^7	10^{16}
L6	10^{-6}	10^3	3×10^7	3×10^{16}	10^7	5×10^3	$1{,}5 \times 10^2$	10^9	10^8	10^{17}
L7	10^{-7}	10^4	3×10^8	3×10^{17}	10^8	5×10^4	$1{,}5 \times 10^3$	10^{10}	10^9	10^{18}
L8	10^{-8}	10^5	3×10^9	3×10^{18}	10^9	5×10^5	$1{,}5 \times 10^4$	10^{11}	10^{10}	10^{19}
L9	10^{-9}	10^6	3×10^{10}	3×10^{19}	10^{10}	5×10^6	$1{,}5 \times 10^5$	10^{12}	10^{11}	10^{20}
L10	10^{-10}	10^7	3×10^{11}	3×10^{20}	10^{11}	5×10^7	$1{,}5 \times 10^6$	10^{13}	10^{12}	10^{21}

NOTE The symbols D, I, R and M relative to the test conditions are explained in Table 4.

A1

3.4 Refractive values of filters and eye-protectors

When assessed in accordance with **4.4**, the maximum refractive values of filters and eye-protectors with no corrective effect shall be as given in Table 2. They apply to the range specified in **7.1.2** of EN 166:1995.

NOTE The requirements of the national standards apply to laser radiation protection filters with a corrective effect up until such times as corresponding European Standards have been prepared.

Table 2 — Maximum refractive values of filters and eye-protectors with no corrective effect

Spherical power	Astigmatic power	Prismatic power difference		
		Horizontal		Vertical
		Base out cm/m	Base in cm/m	cm/m
±0,09	±0,09	0,75	0,25	0,25

3.5 Quality of material and surface of filters

3.5.1 *Material and surface defects*

The material and surface defects of filters shall be assessed in accordance with **4.5.1**.

Except for a marginal area 5 mm wide, filters shall be free from any material or surface defects likely to impair the intended use, such as bubbles, scratches, inclusions, dull spots, mould marks, scoring or other defects originating from the manufacturing process. No holes are allowed anywhere in the filters.

3.5.2 *Scattered light*

The reduced luminous coefficient l^* of a filter, determined in accordance with **4.5.2**, shall not be greater than:

$l^* = 0{,}50$ (cd/m²)/lx

3.6 Stability of filters and eye-protectors to ultraviolet radiation and elevated temperature

3.6.1 *Stability to ultraviolet radiation*

When exposed to ultraviolet radiation in accordance with **4.6**, the properties of filters and eye-protectors shall not change to such an extent that they can no longer satisfy the requirements of **3.1** and **3.3**, **3.4** and **3.5**. The relative change in the luminous transmittance shall be ≤ ±10 %:

$$\left|\frac{\Delta\tau_v}{\tau_v}\right| \leq 10\ \%$$

The spectral transmittance for the laser wavelengths shall, however, in no case exceed the maximum spectral transmittance corresponding to the indicated scale number.

3.6.2 *Stability at elevated temperature*

After the filters and eye-protectors have been stored for 5 h in a climatic cabinet at a temperature of (55 ± 2) °C and a relative humidity of at least 95 %, and then stored for at least 2 h at room temperature, they shall satisfy the requirements of **3.1**, **3.2**, **3.3**, **3.4** and **3.5**. The relative change in the luminous transmittance shall be ≤ ±5 %:

$$\left|\frac{\Delta\tau_v}{\tau_v}\right| \leq 5\ \%$$

The spectral transmittance for the laser wavelength shall, however, in no case exceed the maximum spectral transmittance corresponding to the indicated scale number.

3.7 Resistance of filters and frames to ignition

When tested in accordance with **4.7**, the filters and frames shall not ignite or continue to glow.

3.8 Field of vision of eye-protectors

Eye-protectors shall have a clear field of vision of at least 40° in the vertical and horizontal directions for each eye when measured in accordance with **4.8** (see Figure 1).

3.9 Construction of filters

Filters shall be constructed so that when tested in accordance with **4.3** and **4.9** no splinters are detached from the side of the filter facing the eye. If the filters consist of several individual filters, they shall be assembled in such a way that they cannot be interchanged.

3.10 Frames

〚A1〛 **3.10.1** Filters shall not be interchangeable in the frame.

3.10.2 The frame shall be designed so that no laser radiation can penetrate from the side unintentionally. This requirement is met if for the horizontal angle range α from –50° (nasal side) to +90° (temporal side) the vertical angle β range is protected within the following limit angles in degree (°).

The upward limit β_u of the protected range shall be:

$$\beta_u = 55 - 0{,}001\ 3 \times (\alpha - 12)^2 - 1{,}3 \times 10^{-6} \times (\alpha - 12)^4$$

The downward limit βl of the protected range shall be:

$$\beta l = -70 + 10^{-5} \times (\alpha - 22)^2 + 2{,}3 \times 10^{-6} \times (\alpha - 22)^4$$ 〚/A1〛

3.11 Mechanical strength of eye-protectors

3.11.1 *Basic requirement*

Filters for protection against laser radiation shall be of at least 1,4 mm thickness or satisfy the static bending requirement as specified in **7.1.4.1** of EN 166:1995.

The frames of the eye-protectors shall satisfy the requirements of **7.1.4.2** or **7.2.2** of EN 166:1995.

3.11.2 *Optional requirements*

If the mechanical strength of filters and eye-protectors against laser radiation is to satisfy more stringent requirements, the requirements specified in **7.1.4.2** or the requirements specified in **7.2.2** of EN 166:1995 shall be met.

4 Testing

The testing schedule in Table 3 shall be applied to type testing of filters, frames and complete eye-protectors. The sequence of testing 1 to 9 may be changed. The sequence of testing 13 to 16 may be changed. At least 16 filters or 8 complete eye-protectors are required for testing. If testing for several wavelengths (wavelength ranges) or testing conditions according to **4.3** and/or several optional requirements has to be done, more than 16 samples may be necessary.

Table 3 — Type examination test schedule for filters, frames and complete eye-protectors for protection against laser radiation

Order of testing	Requirement	According to clause	Filter/frame number				
			1 to 3	4 to 6	7 to 16	Depends on specification/requirement	
1	Marking	**6**	+	+			
2	Material and surface defects	**3.5.1**	+	+			
3	Field of vision	**3.8**	1 frame				
4	Construction of filters	**3.9**	+	+			
5	Frames	**3.10**	+	+			
6	Scattered light	**3.5.2**	+	+			
7	Luminous transmittance	**3.2**	+	+			
8	Refractive values	**3.4**	+	+			
9	Prismatic power difference	**3.4**	3 frames				
10	Spectral transmittance at wavelength λ	**3.1**	+	+	3 filters/ frames per λ and test condition	3 filters/ frames per λ and test condition	
11	Stability to UV radiation	**3.6.1**		+			
12	Stability at elevated temperature	**3.6.2**	+				
13	Material and surface defects	**3.5.1**	+	+			
14	Scattered light	**3.5.2**	+	+			
15	Luminous transmittance	**3.2**	+	+			
16	Refractive values	**3.4**	+				
17	Spectral transmittance	**3.1**	+	+			
18	Mechanical strength	**3.11**			+		
19	Stability to laser radiation and spectral transmittance at wavelength λ	**3.3**			3 filters/ frames per λ and test condition	3 filters/ frames per λ and test condition	
20	Ignition	**3.7**			filters/ frames 7 to 9		
21	Optional requirements as given in EN 166:1995	according to applicable clause of EN 166:1995					depends on requirement /test procedure

NOTE Explanation of the symbols: + testing to be carried out on the indicated specimen; empty field: no testing specified.

4.1 Spectral transmittance of filters and frames

The spectral transmittance shall be determined for normal incidence. Filters with angular-dependent transmittance (such as interference layers) for the wavelength range from 400 nm to 1 400 nm shall be measured at angles of incidence between 0° and 30° with polarized radiation. Filters with angular-dependent transmittance for other wavelengths shall be measured at angles of incidence between 0° and 90° with polarized radiation. In this case, the scale number results from the highest of the spectral transmittance values measured.

4.2 Luminous transmittance of filters

The luminous transmittance shall be determined for normal incidence, relative to the D65 standard illuminant (see ISO/CIE 10526:1991 and ISO/CIE 10527:1991).

4.3 Stability [A1] *Text deleted* [A1] to laser radiation

The test shall be carried out with laser radiation of the specified wavelengths and the power and energy densities given in Table 1. The spectral transmittance shall be measured for each laser wavelength during the course of irradiance.

The frame shall be exposed to radiation at the point of least thickness for each of the materials used (with the exception of headbands).

[A1] The diameter d_{63} of the laser beam during this test shall be $\geq 0{,}5$ mm for pulse durations <1 ns.

The diameter d_{63} of the laser beam during this test shall be ≥ 2 mm in all other cases. A beam diameter d_{63} between 0,5 mm and 2,0 mm may be used if the irradiance $E(d)$ or radiant exposure $H(d)$ used at a diameter d is increased compared to the nominal value E_n or H_n, respectively by the factor given by the following formula:

$$E(d)/E_n = a_0 + a_1 \times e^{-d/a_2} \text{ or } H(d)/H_n = a_0 + a_1 \times e^{-d/a_2}$$

where the constants are in the case of filters consisting of:

— glass or containing glass

$a_0 = 0{,}769$, $a_1 = 18{,}29$, $a_2 = 0{,}477\ 8$;

— plastics

$a_0 = 1$, $a_1 = 5{,}66$, $a_2 = 0{,}449\ 8$.

In the case of rectangular beams, the dimensions specified apply to the shortest side of the rectangle.

NOTE The number of decimals of the coefficients was chosen to give a smooth transition at a 2 mm beam diameter. It should not be interpreted as a requirement for measurement accuracy. [A1]

The duration of the test shall be taken from Table 4.

Table 4 — Duration of test for filters and eye-protectors against laser radiation

Test conditions for laser type	Typical laser type	Pulse length s	Number of pulses
D	Continuous wave laser	10	1
I	Pulsed laser	10^{-4} to 10^{-1}	100
R	Q switch pulsed laser	10^{-9} to 10^{-7}	100
M	Mode-coupled pulsed laser	$<10^{-9}$	100

NOTE The pulse lengths for test conditions I and R do not follow consecutively. Neither are they a continuation of the length for test condition D. The pulse lengths indicated are characteristic values of typical lasers. It is recommended to use a laser with a pulse length in this range.

All laser radiation protective filters shall be tested in accordance with the test condition D. If no CW laser is available for a specific wavelength, a pulse laser at a minimum pulse repetition frequency of 5 Hz may be used.

If additional protection against pulsed lasers is required, the filters and laser radiation eye-protectors shall be tested according to one or several of the test conditions I, R, or M.

4.4 Refractive value of filters and eye-protectors

The test shall be carried out in accordance with Clause **3** of EN 167:1995.

4.5 Quality of material and surface of filters

4.5.1 *Material and surface defects*

The test shall be carried out in accordance with Clause **5** of EN 167:1995.

NOTE The thin layered filters should be very carefully examined, as the protection could be affected if the vacuum deposited layer were damaged (e.g. by scratches and holes).

4.5.2 *Scattered light*

The test shall be carried out in accordance with Clause **4** of EN 167:1995.

4.6 Stability to UV radiation

The test shall be carried out in accordance with Clause **6** of EN 168:1995, with the lamp running at a power of 450 W and an exposure time of (50 ± 0,2) h.

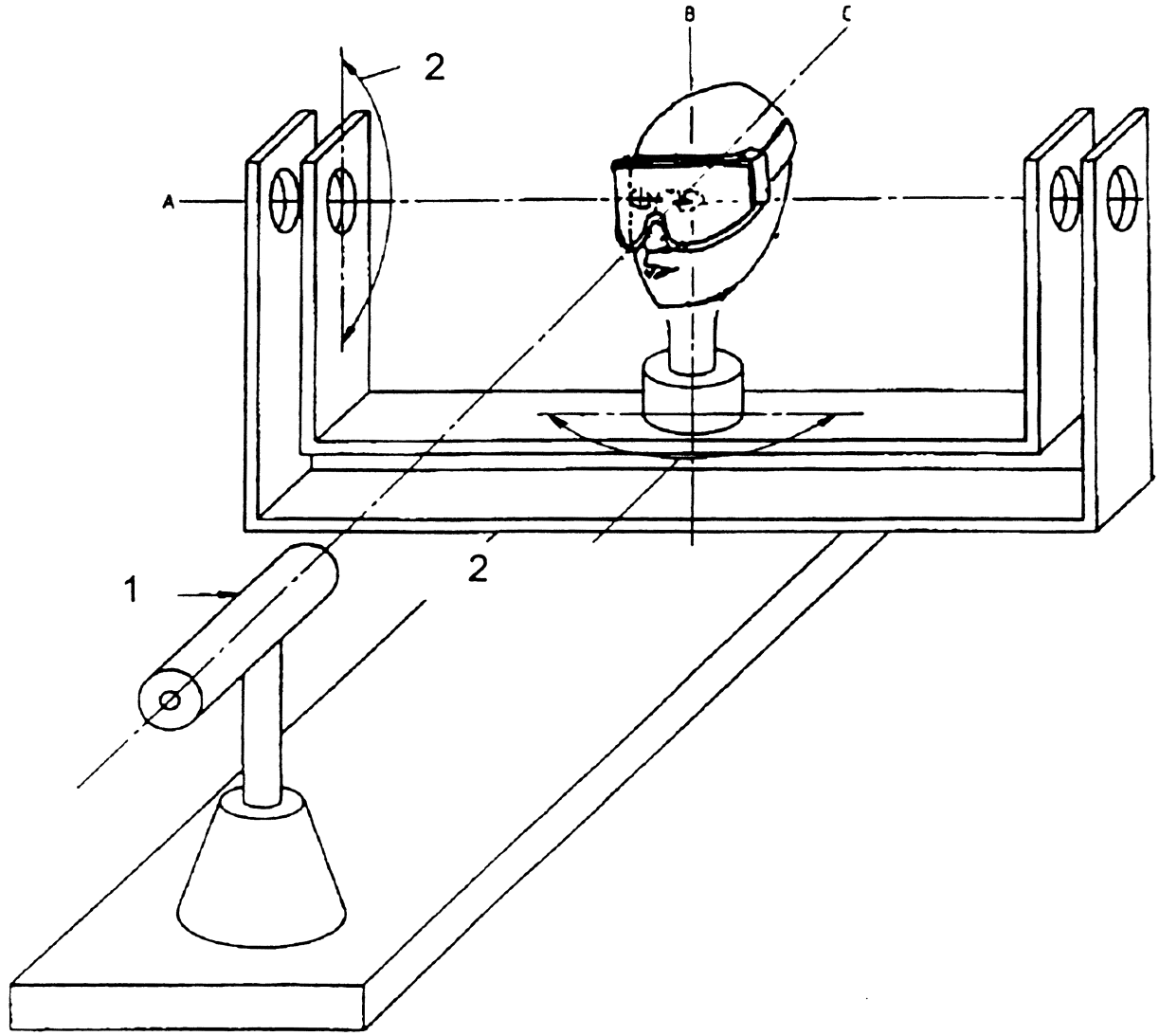
4.7 Resistance of filters and frames to ignition

The test shall be carried out in accordance with Clause **7** of EN 168:1995.

4.8 Field of vision of eye-protectors

For measuring the field of vision, the test head specified in EN 168:1995 with the eye-protector without filters shall be mounted as shown in the example of set up illustrated in Figure 1 so that the two axes of rotation A and B and the optical axis C intersect in the middle of the front surface of one eye. Radiation is provided by a laser beam of maximum diameter 5 mm along axis C, for example. When rotated around axis A, the difference in the angular positions at which the light beam no longer hits the eye gives the vertical field of vision. By rotating around axis B, the difference between the angular position at which the light beam no longer hits the eye and the line of vision of the test head parallel to the optical axis C gives half the horizontal field of vision.

Other methods are permissible if they give identical results.



1) Laser
2) At least 40°

Figure 1 — Example of test set-up for the measurement of field of vision

4.9 Construction of filters

The test shall be carried out by means of visual inspection.

4.10 Frames

[A1] **4.10.1** It shall be tested by means of visual inspection whether the filters are interchangeable.

4.10.2 The test shall be carried out using the method given in **4.8**. The zero values of the angles α and β are reached when the axis, A, B and C of the test apparatus are perpendicular to each other. [A1]

4.11 Mechanical strength

The test shall be carried out in accordance with Clause **4** of EN 168:1995.

5 Information supplied by the manufacturer

The information shall be in the language(s) of the country in which the eye-protector is sold.

The selection criteria and instructions for use shall contain at least the following data:

a) luminous transmittance;

b) if the luminous transmittance is less than 20 %, this shall be indicated and the user shall be recommended to increase the intensity of illumination at the workplace;

c) in the case of tinted filters a warning to the user to check if the recognition of warning lights or warning signals is impaired;

d) the information that eye-protectors are only intended to give protection against accidental radiation and that both the limiting values and the stability tests are based on a maximum period of 10 s;

e) the information that eye-protectors and filters against laser radiation which have been damaged or which have undergone a colour change should not be used any more;

f) an explanation of the symbols used in the marking;

g) the note that the limiting values as specified in Annex A have been simplified on the safe side compared with the limiting values in EN 60825-1:1994. If the user wishes to use the EN 60825-1:1994 values, he shall carry out a special test to see whether the stability of the eye-protectors against laser radiation is adequate for the specified application;

h) details regarding an appropriate cleaning method;

i) a warning that damaged eye-protection and eye-protection with scratched oculars has to be replaced.

Instructions shall also indicate that hazards may arise because of accidental reflection of laser radiation, e.g. by reflection from reflective parts (including eye-protectors), tilting or maladjustment of optical components.

Instructions shall also indicate that all personnel working in areas where there is a risk of exposure to hazardous laser radiation should wear appropriate eye-protection.

In addition, the manufacturer shall supply additional data in the form of transmission curves.

6 Marking

6.1 Eye-protectors

[A1] The following elements shall be marked permanently on the filters or the frames for identification:

a) wavelength(s) or wavelength range (given in nm) in which the filter provides protection;

b) the symbol for the test condition;

c) scale number;

If the filter guarantees protection in one or several spectral ranges, the lowest scale number shall be given in the corresponding spectral range:

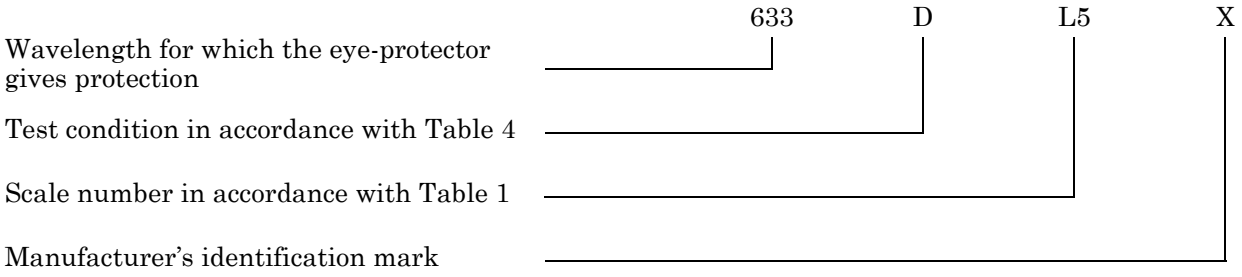
d) manufacturer's identification mark;

In order to prevent multiple use, only marks granted at European or national level shall be used.

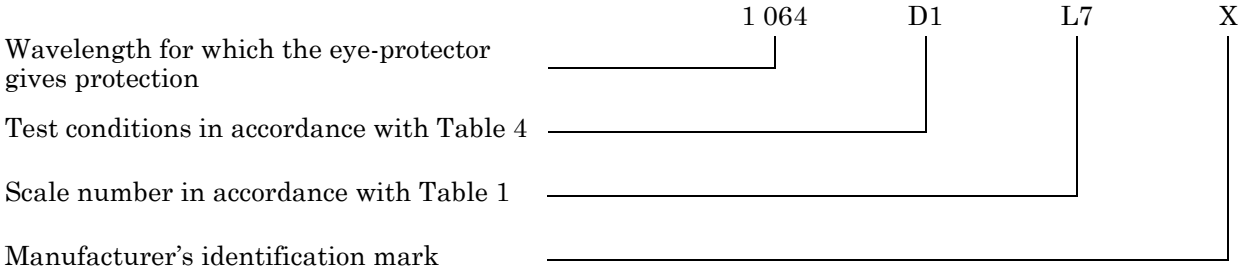
e) if the eye-protector satisfies the mechanical strength requirement in **3.11**, one of the marks specified in Clause **9** of EN 166:2001 shall also be added. [A1]

A1 If the symbols are marked on the filters, they shall not impair vision nor the protective effect.

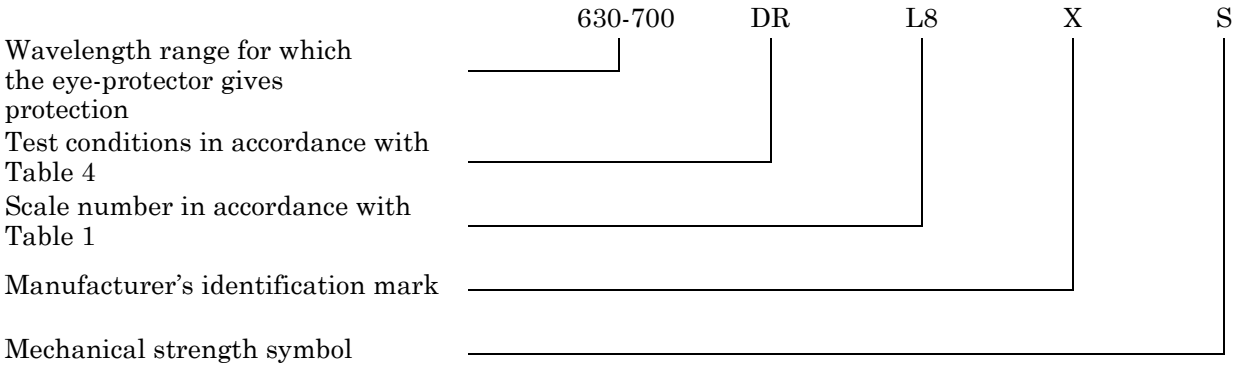
EXAMPLE 1:



EXAMPLE 2:



EXAMPLE 3:



If several marks apply to a laser radiation eye-protector, all these marks shall be applied, or alternatively the manufacturer's identification mark, the certification mark and the mechanical strength symbol shall be specified only once; the other identification elements shall be separated by a +.

EXAMPLE 4:

Marking can become very lengthy if a filter or a frame protects against several wavelength. In these cases, the mark may be pooled as follows:

10600 D L3 + IR L4

1064 DI L8 + R L 9

633 D L4 + IR L5

X S

where the symbols have the same meaning as in precedent examples. A1

6.2 Filters

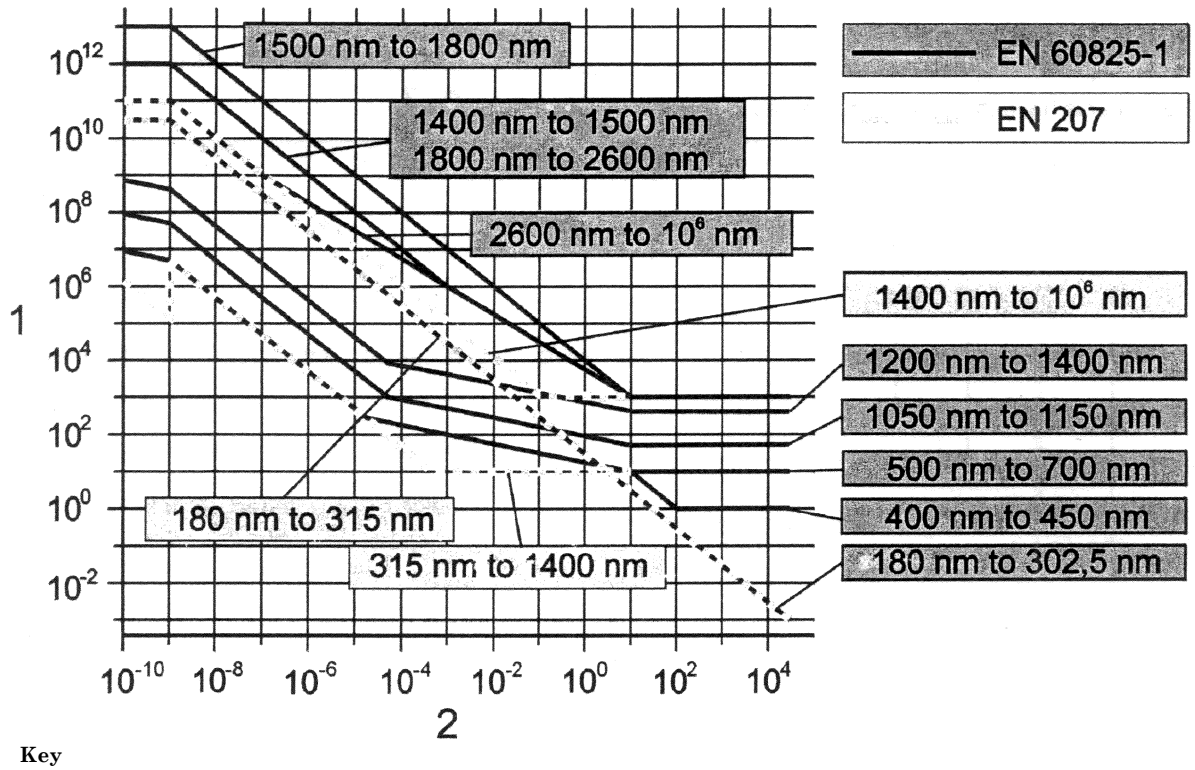
As filters in eye-protectors against laser radiation shall not be interchanged, they need not be marked separately if the complete eye-protectors are marked.

Filters to be used as viewing windows in appliances and installations shall be marked as defined in **6.1**.

Annex A (informative) Principles

A.1 Limiting values and time base

The maximum permissible radiation on the cornea is specified in EN 60825-1:1994. These limiting values indicate a complicated dependency on time and wavelength. Therefore, this standard uses a simplified set of figures which either agree with these limiting values or are on the safe side of them. In the wavelength range 180 nm to 315 nm, the permissible limiting values for 30 000 s were used, otherwise the permissible limiting values for a 10 s period of radiant exposure. The simplified values can be taken from Table A.1. Figure A.1 compares the values in EN 60825-1:1994 and those in Table A.1.



Key

1 Irradiance/W/m^2

2 Exposure duration/s A1

Figure A.1 — Comparison of the limiting values specified in EN 60825-1 and the simplified values of EN 207

A.2 Beam areas

EN 60825-1:1994 specifies diameters which are to be used for averaging when calculating the energy density and power density. In the wavelength range 400 nm to 1 400 nm, this is a diameter of 7 mm corresponding to an area of 38,5 mm^2. As a number of typical lasers (e.g. argon lasers, He–Ne lasers, Nd–YAG lasers) in this wavelength range have a beam diameter of approximately 1 mm, the power/energy density in their beam is considerably higher than if an average was calculated over a cross-sectional area of 38,5 mm^2. If the actual beam diameter is used when calculating the power/energy density, a greater degree of protection is obtained than that which is obtained when selecting the scale numbers in accordance with Annex B. As the filters are limited technically not by their absorption, but by their stability to laser radiation, the beam area (A) based on the actual beam diameter is used in this standard when calculating the power/energy density.

Generally, the smallest accessible beam diameter is used for the calculation.

In the case of diverging laser radiation (e.g. from the ends of optical fibres or diode lasers) the beam diameter 10 cm from the divergence point may be used as a basis for calculating the power density and energy density.

Table A.1 — Simplified maximum permissible irradiance values for the cornea

Wavelength range	Irradiance *E*				Radiant exposure *H*	
	D		M		I, R	
	Pulse duration s	W/m²	Pulse duration s	W/m²	Pulse duration s	J/m²
180 to 315	≥ 30 000	0,001	$<10^{-9}$	3×10^{10}	10^{-9} to 3×10^{4}	30
over 315 to 1 400	$>5 \times 10^{-4}$ to 10	10	$<10^{-9}$	5×10^{6}	10^{-9} to 5×10^{-4}	0,005
over 1 400 to 10^{6}	>0,1 to 10	1 000	$<10^{-9}$	10^{11}	10^{-9} to 0,1	100

A.3 Angle dependence

The measurements of the angle dependence of the spectral transmittance is limited to the angle range from 0° to 30° for filters covering the wavelength range between 400 nm and 1 400 nm. This limitation of the angle range is justified by the fact that eye movements for the fixation of an object are usually limited to a maximum angle of 15°. For objects which would appear under a larger angle the head would move.

Annex B (informative)
Recommendations for the use of laser radiation eye-protectors

This annex gives recommendations as to the selection of laser radiation eye-protectors depending on the type of laser and the operating conditions.

Before selecting eye protection a risk assessment must first be undertaken and the risk minimized by engineering and administrative controls. Control methods are outlined in EN 60825-1:1994 and applicable national regulations.

Filters for viewing windows should be connected in a way so that they are able to withstand incident laser radiation for as long as it could be there.

NOTE The information contained in Table B.1 is equivalent to that of Table 1 of **3.1** and is reminded here in order to facilitate the application of this standard.

B.1 Types of lasers

〉A1〈 It is possible to make a distinction between the different types of lasers according to their duration of operation and pulse length. The significance of the symbols D, I, R, and M is given in Table B.2. 〉A1〈

Table B.1 — Recommended scale numbers for use of filters and eye protectors against laser radiation

Scale number	Maximum spectral transmittance at the laser wavelength	Maximum power (E) and energy (H) density in the wavelength range								
		180 nm to 315 nm			>315 nm to 1 400 nm			>1 400 nm to 1 000 µm		
		Laser type/exposure duration in s								
		D $\geq 3 \times 10^4$	**I, R** 10^{-9} to 3×10^4	**M** $<10^{-9}$	**D** $>5 \times 10^{-4}$	**I, R** 10^{-9} to 5×10^{-4}	**M** $<10^{-9}$	**D** >0,1	**I, R** 10^{-9} to 0,1	**M** $<10^{-9}$
	$\tau(\lambda)$	E_D W/m²	$H_{I,R}$ J/m²	E_M W/m²	E_D W/m²	$H_{I,R}$ J/m²	H_M J/m²	E_D W/m²	$H_{I,R}$ J/m²	E_M W/m²
L1	10^{-1}	0,01	3×10^2	3×10^{11}	10^2	0,05	$1,5 \times 10^{-3}$	10^4	10^3	10^{12}
L2	10^{-2}	0,1	3×10^3	3×10^{12}	10^3	0,5	$1,5 \times 10^{-2}$	10^5	10^4	10^{13}
L3	10^{-3}	1	3×10^4	3×10^{13}	10^4	5	0,15	10^6	10^5	10^{14}
L4	10^{-4}	10	3×10^5	3×10^{14}	10^5	50	1,5	10^7	10^6	10^{15}
L5	10^{-5}	10^2	3×10^6	3×10^{15}	10^6	5×10^2	15	10^8	10^7	10^{16}
L6	10^{-6}	10^3	3×10^7	3×10^{16}	10^7	5×10^3	$1,5 \times 10^2$	10^9	10^8	10^{17}
L7	10^{-7}	10^4	3×10^8	3×10^{17}	10^8	5×10^4	$1,5 \times 10^3$	10^{10}	10^9	10^{18}
L8	10^{-8}	10^5	3×10^9	3×10^{18}	10^9	5×10^5	$1,5 \times 10^4$	10^{11}	10^{10}	10^{19}
L9	10^{-9}	10^6	3×10^{10}	3×10^{19}	10^{10}	5×10^6	$1,5 \times 10^5$	10^{12}	10^{11}	10^{20}
L10	10^{-10}	10^7	3×10^{11}	3×10^{20}	10^{11}	5×10^7	$1,5 \times 10^6$	10^{13}	10^{12}	10^{21}

Table B.2 — Key to symbols D, I, R, M:

Symbol	Laser designation	Typical pulse duration s
D	Continuous wave (CW) laser	>0,25
I	Pulsed laser	$>10^{-6}$ to 0,25
R	Giant-pulsed laser	$>10^{-9}$ to 10^{-6}
M	Mode-coupled pulsed laser	$<10^{-9}$

B.2 Determination of the scale number

In the following calculations of the power density or energy density, the actual beam area (i.e. the area of the smallest circle containing 63 % of the laser power and energy) should be used. For non-circular cross-sections, a similar procedure should be employed and the smallest rectangle containing 63 % of the laser power and energy should be used.

B.2.1 *Continuous wave laser (D)*

The power density E of the laser beam is calculated from the laser power P and from the beam area A as follows:

$$E = \frac{P}{A}$$

The required scale number can then be deduced from column D of Table B.1 corresponding to the wavelength of the laser.

B.2.2 ***Pulsed lasers***

According to EN 60825-1:1994, the maximum permissible exposure for wavelengths from 400 nm to 10^6 nm is determined by using the most restrictive of requirements a), b) and c) as appropriate. For wavelengths smaller than 400 nm the permissible exposure is determined by using the most restrictive of requirements a) and b).

a) The exposure from any single pulse within a pulse train shall not exceed the permissible exposure for a single pulse.

b) The average power for a pulse train of duration T shall not exceed the power corresponding to the permissible exposure for a single pulse of duration T.

c) The exposure from any single pulse within a pulse train shall not exceed the permissible exposure for a single pulse multiplied by the correction factor C_5. C_5 is only applicable to pulse durations shorter than 0,25 s.

where

C_5 $= N^{-¼}$;

N is the number of pulses in the pulse train during the expected exposure duration T.

If the pulse repetition frequency of the laser is υ, then the total number N of pulses within an exposure duration T, which in this standard is taken to be 10 s, is:

$N = \upsilon \times 10$ s

According to this, in the case of pulsed lasers the scale number has to be evaluated according to **B.2.2.1** or **B.2.2.2** and additionally according to **B.2.1**. These two evaluations will in many cases lead to different scale numbers. The higher of the two scale numbers shall be used.

B.2.2.1 *Pulse duration* $\geq 10^{-9}$ *s (I and R)*

The energy density H of the laser beam is calculated from the pulse energy Q and the beam cross section A as follows:

$$H = \frac{Q}{A}$$

For lasers in the wavelength range 400 nm to 1 400 nm, this value of the energy density shall be multiplied by $N^{¼}$:

$H' = H \times N^{¼}$

Then, for H', the necessary scale number shall be taken from column I or R (see Table B.1) corresponding to the wavelength and type of laser.

B.2.2.2 *Mode-coupled lasers: pulse duration* $< 10^{-9}$ *s (M)*

The calculation can be done as defined in **B.2.1** using the peak power of the individual pulses for laser power P. In addition, calculate H' as described in **B.2.2** for lasers in the wavelength range 400 nm to 1 400 nm and read off the required scale number.

B.3 Time base

The laser radiation eye-protectors specified in Table B.1 are not suitable for continuous exposure to a laser beam. The protection has been designed on the basis of 10 s with regard to transmission (attenuation of the laser beam) for wavelength in the range above 400 nm, otherwise on the basis of 30 000 s. Stability to laser radiation is tested for 10 s in both cases.

If the user wishes, in special cases, to use a time base greater than 10 s even for wavelengths greater than 400 nm, he should select the correspondingly higher scale numbers taking into account the permissible limiting values in EN 60825-1:1994.

B.4 Filters in appliances

Laser radiation protective filters can be used as inspection windows in shielding applications and in laser appliances. Depending on the time base used (see **B.3**) and the test conditions (see **4.3**), they should mainly afford protection against accidental radiation exposure.

If they are to reduce the radiation to below the limit values for continuous radiation, a filter of the next highest scale number should be used taking EN 60825-1:1994 into consideration. The manufacturer of the appliance should ensure its stability to laser radiation over the entire period of operation.

Annex ZA (informative)
Clauses of this European Standard addressing essential requirements or other provisions of EU Directives

This European Standard has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association and supports essential requirements of EU Directive 89/686/EEC.

WARNING. Other requirements and other EU Directives may be applicable to the product(s) falling within the scope of this standard.

The following clauses of this standard are likely to support requirements of Directive 89/686/EEC, Annex II.

EU Directive 89/686/EEC, Annex II		Clauses of this standard
1.1	Design principles	**3.1**, **3.2**, **3.3**, **3.4**, **3.5**, **3.8**
1.2	Innocuousness of PPE	**3.3**, **3.4**, **3.5**, **3.6**, **3.7**, **3.8**
1.3	Comfort and efficiency	**3.2**, **3.5**, **3.6**, **3.7**, **3.8**, **3.11**
1.4	Information supplied by the manufacturer	**5**, **6**
2.3	PPE for the face, eyes and respiratory tracts	**3.8**
2.4	PPE subject to ageing	**3.6**
2.12	PPE bearing one or more identification or recognition marks directly or indirectly relating to health and safety	**6**
3.1	Protection against mechanical impact	**3.11**
3.9.1	Non-ionizing radiation	**3.1**, **3.3**, **3.10**

Compliance with the clauses of this standard provides one means of conforming with the specific essential requirements of the directives concerned and associated with EFTA regulations.

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