BRITISH STANDARD

BS EN 208:2009

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

ICS 13.340.20

National foreword

This British Standard is the UK implementation of EN 208:2009. It supersedes BS EN 208:1999 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee PH/2, Eye protection.

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

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

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Persönlicher Augenschutz - Augenschutzgeräte für Justierarbeiten an Lasern und Laseraufbauten (Laser-Justierbrillen)

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Foreword

This document (EN 208:2009) has been prepared by Technical Committee CEN/TC 85 “Eye protective equipment”, the secretariat of which is held by AFNOR.

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of an identical text or by endorsement, at the latest by June 2010, and conflicting national standards shall be withdrawn at the latest by June 2010.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN 208:1998.

This document 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 document.

The significant technical changes between this European Standard and the previous edition are detailed in Annex C.

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

1 Scope

This European Standard applies to laser adjustment filters and eye-protectors. These are filters and eye-protectors for use in adjustment work on lasers and laser systems as defined in EN 60825-1:2007 where hazardous radiation occurs in the visible spectral range of 400 nm to 700 nm. Filters specified in this European Standard reduce this radiation to values defined for lasers of class 2 (≤ 1 mW for CW (continuous wave) lasers).

This European Standard defines the requirements, test methods and marking. A guide is given in Annex B with regard to selection and use.

EN 207 applies to eye-protection against accidental exposure to laser radiation.

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

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 166:2001, *Personal eye-protection — Specifications*

EN 167:2001, *Personal eye-protection — Optical test methods*

EN 168:2001, *Personal eye-protection — Non-optical test methods*

EN 207:2009, *Personal eye-protection equipment — Filters and eye-protectors against laser radiation (laser eye-protectors)*

ISO 11664-1:2007, *Colorimetry — Part 1: CIE standard colorimetric observers*

ISO 11664-2:2007, *Colorimetry — Part 2: CIE standard illuminants*

3 Requirements

3.1 Spectral transmittance of filters and frames

When tested according to 4.2, the spectral transmittance values of the filters and the frames for the laser wavelength shall be as given in Table 1.

Table 1 — Scale numbers, spectral transmittance and maximum laser power

Scale number	Spectral transmittance		CW and pulse lasers with a pulse duration of $\geq 2 \times 10^{-4}$ s	Pulse lasers with a pulse duration of $> 10^{-9}$ s to 2×10^{-4} s
	Filter	Frame	Maximum laser power W	Maximum pulse energy J
RB 1	$10^{-2} < \tau(\lambda) \leq 10^{-1}$	$\tau(\lambda) \leq 10^{-1}$	0,01	2×10^{-6}
RB 2	$10^{-3} < \tau(\lambda) \leq 10^{-2}$	$\tau(\lambda) \leq 10^{-2}$	0,1	2×10^{-5}
RB 3	$10^{-4} < \tau(\lambda) \leq 10^{-3}$	$\tau(\lambda) \leq 10^{-3}$	1	2×10^{-4}
RB 4	$10^{-5} < \tau(\lambda) \leq 10^{-4}$	$\tau(\lambda) \leq 10^{-4}$	10	2×10^{-3}
RB 5	$10^{-6} < \tau(\lambda) \leq 10^{-5}$	$\tau(\lambda) \leq 10^{-5}$	100	2×10^{-2}

3.2 Luminous transmittance of filters

When tested in accordance with 4.3, the luminous transmittance of the filter relative to the D65 standard illuminant (see ISO 11664-2:2007) shall be at least 20 %. However, luminous transmittance lower than 20 % can be accepted provided that the manufacturer supplies information related to the increase of the intensity of illumination at the relevant workplace in accordance with Clause 5.

3.3 Resistance of filters and frames to laser radiation

When tested according to 4.4, 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*) as specified in Table 2 for a period of at least 5 s and for 50 pulses in case of pulsed lasers. The values of energy density (*H*) for testing the resistance against laser radiation for pulsed lasers should be multiplied with the factor $N^{-1/4}$, where N is the number of pulses in 5 s, if the pulse durations is between 10^{-9} and 2×10^{-4} s and the pulse series is fast (frequency > 0,1 s^{-1}). The eye-protector 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 during the course of irradiation is not considered negative if the protective effect is still maintained.

Table 2 — Power density and energy density for testing

Scale number	Power density *E* W/m^2	Energy density *H* J/m^2
RB 1	1×10^4	2
RB 2	1×10^5	20
RB 3	1×10^6	200
RB 4	1×10^7	2 000
RB 5	1×10^8	20 000

3.4 Refractive values of filters and eye-protectors

When tested in accordance with 4.5, the maximum refractive values of filters and eye-protectors with no corrective effect shall be as given in Table 3. They apply for the range specified in EN 166.

Table 3 — Maximum refractive values of filters and eye-protectors with no corrective effect

Spherical power	Astigmatic power	Prismatic power difference		
		horizontal		vertical
		base out	base in	
m^{-1}	m^{-1}	cm/m	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 tested in accordance with 4.6.1.

Except for a marginal area of 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 Diffusion of light

The reduced luminous coefficient *l** of a filter, determined in accordance with 4.6.2, shall not be greater than

$$l^* = 0{,}50 \ \frac{\text{cd} / \text{m}^2}{\text{lx}} \qquad (1)$$

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

3.6.1 Stability to ultraviolet radiation

When exposed to ultraviolet radiation in accordance with 4.7.1, 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, 3.2, 3.4 and 3.5. The relative change in the luminous transmittance shall not exceed 10 %.

$$\left| \frac{\Delta \tau_v}{\tau_v} \right| \leq 10\ \% \qquad (2)$$

The spectral transmittance for the laser wavelengths shall, however, in no case exceed the maximum spectral transmittance corresponding to the indicated scale number (see Table 1).

3.6.2 Stability to elevated temperature

After exposure to elevated temperature in accordance to 4.7.2, filters and eye-protectors shall satisfy the requirements of 3.1, 3.2, 3.4 and 3.5. The relative change in the luminous transmittance shall not exceed 5 %.

$$\left| \frac{\Delta \tau_v}{\tau_v} \right| \leq 5\ \% \qquad (3)$$

The spectral transmittance for the laser wavelengths shall, however, in no case exceed the maximum spectral transmittance corresponding to the indicated scale number (see Table 1).

3.7 Resistance of filters and frames to ignition by contact with hot surfaces

When tested in accordance with 4.8, 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 4.9.

3.9 Construction of filters

Filters shall be constructed so that when tested in accordance with 4.4 followed by a visual inspection 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 Construction of frames

3.10.1 Filters shall not be interchangeable in the frame. An exception is possible if the protection to laser radiation is determined only by the filter(s) and no part of the frame lies inside the protected range as defined below. In such a case the marking of the eye-protector shall be on the filter(s) and there is no requirement for the frame to satisfy 3.3 on resistance to laser radiation.

3.10.2 The frame shall be designed so that no laser radiation can penetrate from the side. 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 degrees (°).

The upward limit β_u of the protected range shall be:

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

The downward limit β_l of the protected range shall be:

$$\beta_l = -70 + 10^{-5}\,(\alpha - 12)^2 + 2{,}3 \times 10^{-6}\,(\alpha - 22)^4 \quad (5)$$

Testing shall be done in accordance with 4.10.

3.11 Mechanical strength of eye-protectors

3.11.1 Basic requirement

Filters for protection against laser radiation shall satisfy the requirement for minimum robustness as specified in 7.1.4.1 of EN 166:2001.

The frames of the eye-protectors shall satisfy the requirements of 7.1.4.2 or 7.2.2 of EN 166:2001.

3.11.2 Optional requirement

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 and 7.2.2 of EN 166:2001 shall be met.

4 Testing

4.1 General

The testing schedule in Table 4 shall be applied to testing of filters, frames and complete eye-protectors for laser adjustment work. The sequences of testing 1 to 9 and 13 to 16 may be changed. At least 16 filters or eight complete eye-protectors are required for testing. If testing for several wavelengths (wavelength ranges) or testing conditions according to 4.4 and/or several optional requirements has to be done, more than 16 samples may be necessary.

Table 4 — Test schedule for filters, frames and complete eye-protectors for laser adjustment work

Order of testing	Requirements	According to Clause	Number of filter/frame samples				
			3	3	10	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	Construction of frames	3.10	+	+			
6	Diffusion of light	3.5.2	+	+			
7	Luminous transmittance	3.2	+	+			
8	Refractive values	3.4	+	+			
9	Prismatic power difference	3.4	+	+			
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 to elevated temperature	3.6.2	+				
13	Material and surface defects	3.5.1	+	+			
14	Diffusion of light	3.5.2	+	+			
15	Luminous transmittance	3.2	+	+			
16	Refractive values	3.4	+				

Table 4 (*continued*)

Order of testing	Requirements	According to Clause	Number of filter/frame samples				
			3	3	10	Depends on specification/requirement	
17	Spectral transmittance	3.1	+	+			
18	Mechanical strength	3.11			+		
19	Resistance 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			3 filters/frames		
21	Optional requirements as given in EN 166	According to applicable clause of EN 166:2001					Depends on requirement/test procedure
Explanation of the symbols:		+	Testing to be carried out on the indicated specimen;				
		Empty field	No testing specified.				

4.2 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 700 nm shall be measured at angles of incidence between 0° and 30° with polarized radiation and an orientation of the polarization direction giving the highest value of the spectral transmittance. The spectral transmittance specification of Table 1 shall be met at 0°. At other angles the spectral transmittance shall be within the range specified or lower than the value given in Table 1.

Testing shall be done in accordance with EN 167:2001, Clause 6.

4.3 Luminous transmittance of filters

The luminous transmittance shall be determined for normal incidence, relative to the D65 standard illuminant (see ISO 11664-1:2007 and ISO 11664-2:2007).

The test shall be performed according to EN 167:2001, Clause 6.

4.4 Resistance of filters and frames to laser radiation

The test method shall be as specified in EN 207:2009, 4.4.

4.5 Refractive value of filters and eye-protectors

The test shall be carried out in accordance with EN 167:2001, Clause 3.

4.6 Quality of material and surface of filters

4.6.1 Material and surface defects

The test shall be carried out in accordance with EN 167:2001, Clause 5.

NOTE Thin film filters should be carefully examined for defects (scratches, holes), as damage of deposited layer can affect protection against laser radiation.

4.6.2 Diffusion of light

The test shall be carried out in accordance with EN 167:2001, Clause 4.

If the simplified method cannot be used because the spectral transmittance is too low, the basic method shall be used.

4.7 Stability to UV radiation and stability to elevated temperature

4.7.1 Stability to UV radiation

The test shall be carried out in accordance with Clause 6 of EN 168:2001, with the lamp running at a power of 450 W and an exposure time of (50 ± 0,2) h.

4.7.2 Stability to elevated temperature

Filters and eye-protectors shall be stored for at least 7 h in a climatic cabinet at a temperature of (55 ± 2) °C and a relative humidity of > 60 %, and then stored for at least 2 h at room temperature.

4.8 Resistance of filters and frames to ignition by contact with hot surfaces

The test shall be carried out in accordance with EN 168:2001, Clause 7.

4.9 Field of vision of eye-protectors

The test shall be carried out in accordance with 4.9 of EN 207:2009.

4.10 Determination of the protected range

Using the apparatus as given in EN 207:2009, 4.9 the scan shall verify that the eye-protector covers at least the range as defined by the limits β_u and β_l.

4.11 Frames

4.11.1 It shall be tested by means of manual and visual inspection whether the filters are interchangeable.

4.11.2 The test shall be carried out using the method given in 4.9. 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.

4.12 Mechanical strength

The test shall be carried out in accordance with EN 168:2001, Clause 4.

5 Information supplied by the manufacturer

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

In addition to the requirements of EN 166:2001, Clause 10, the information provided shall contain at least the following:

a) the eye-protector only affords protection against laser radiation:

up to	0,01 W	and up to 2×10^{-6} J for scale number RB 1;
up to	0,1 W	and up to 2×10^{-5} J for scale number RB 2;
up to	1 W	and up to 2×10^{-4} J for scale number RB 3;
up to	10 W	and up to 2×10^{-3} J for scale number RB 4;
up to	100 W	and up to 2×10^{-2} J for scale number RB 5;

b) information that the eye-protector is not intended to be used for looking directly into the beam;

c) the information that eye-protectors are only intended to give protection against accidental exposure to laser radiation and the user shall perform active aversion response, if glare caused by the laser beam is noticed;

d) details regarding an appropriate cleaning method;

e) a warning that eye-protectors and filters against laser radiation which have been damaged, have scratched oculars or which have undergone a colour change shall not be used any more;

f) the value for the luminous transmittance. 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;

g) in the case of tinted and coloured filters a warning that the recognition of warning lights or warning signals can be impaired;

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

i) a warning, that hazards may arise because of accidental reflection of laser radiation, e.g. by reflection from reflective parts (including eye-protectors), tilting or misalignment of optical components. All personnel working in these areas shall wear eye-protectors;

j) in case of filters with angle dependent transmittance an information shall be given that the protection is only provided for angles of incidence up to 30°.

6 Marking

The following shall be marked permanently on the filters or frames for identification:

a) maximum laser power in Watt (W) and maximum pulse energy in joules (J) for which the filters provide protection;

b) wavelength or wavelength range, in nanometres (nm), for which the eye-protector is specified;

c) scale number;

d) if the eye-protector is not tested with low repetition rates (≤ 25 Hz), the suffix Y shall be added to the scale number, e.g. RB5Y;

e) manufacturer's identification mark.

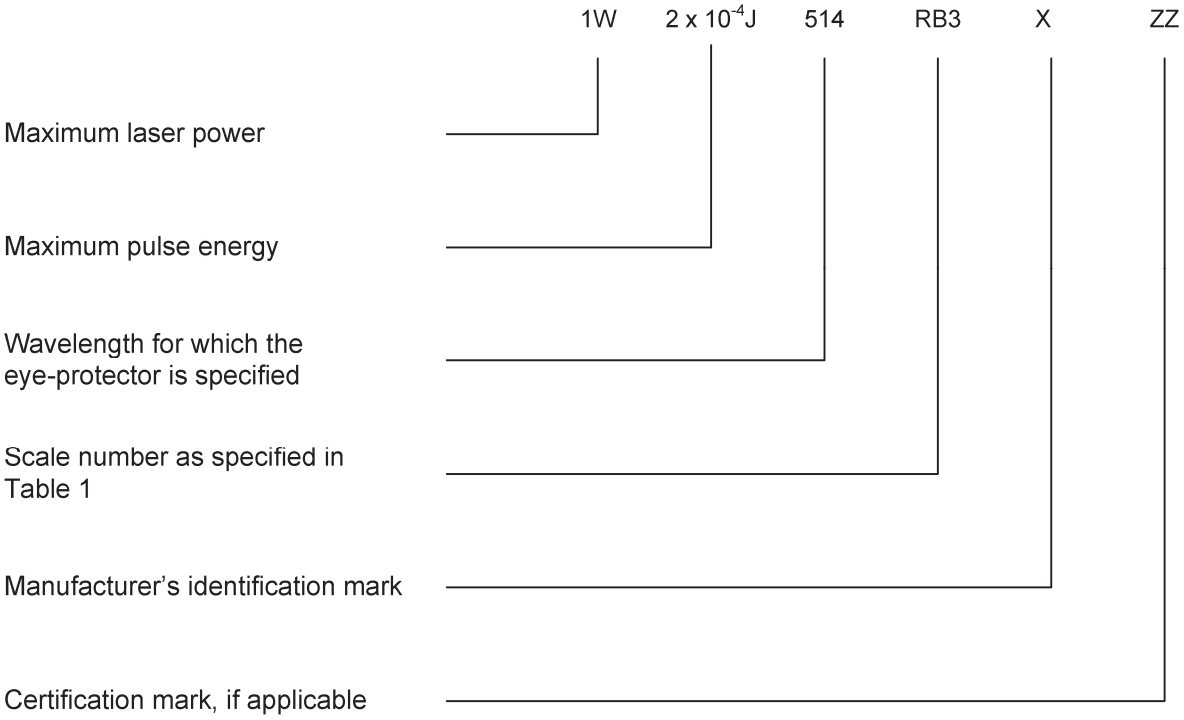
In order to prevent multiple use, only marks granted at European or national level shall be used;

f) certification mark, if applicable;

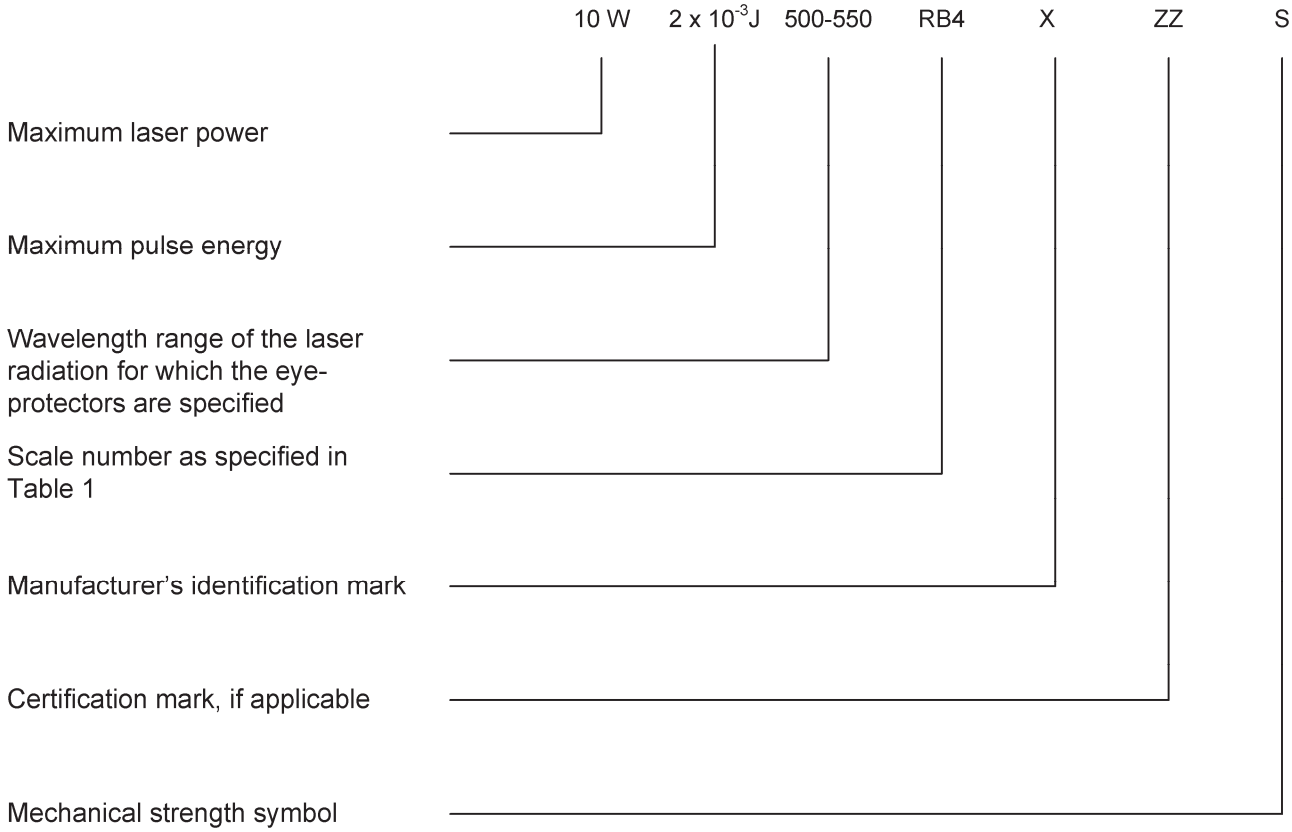
g) on the frame the words "adjustment eye-protectors" in the language(s) of the country in which the eye-protector will be sold;

h) if the eye-protector satisfies the mechanical strength requirements of 3.11.2, one of the symbols specified in Clause 9 of EN 166:2001 shall be added.

EXAMPLE 1



EXAMPLE 2



Annex A
(informative)

Principle

A.1 Class 2 lasers

The laser classes are defined in EN 60825-1. The following summarizes the definition of class 2 lasers as can be taken from 9.2 of EN 60825-1:2007:

Class 2 lasers are low-power devices which emit visible radiation (in the wavelength range 400 nm to 700 nm) and which are capable of operating either in the continuous wave or pulsed mode. For exposure periods of up to 0,25 s, the output power or energy of these devices is limited to the limit values of accessible radiation (AEL) for class 1. The limit is 1 mW for a continuous wave laser and 2×10^{-7} J for a single pulse of pulsed lasers.

NOTE In order to distinguish CW lasers from pulsed lasers from a time point of view, this European Standard has been simplified in comparison with EN 60825-1:2007. Figure A.1 shows a comparison between the EN 60825-1:2007 values and those of this European Standard.

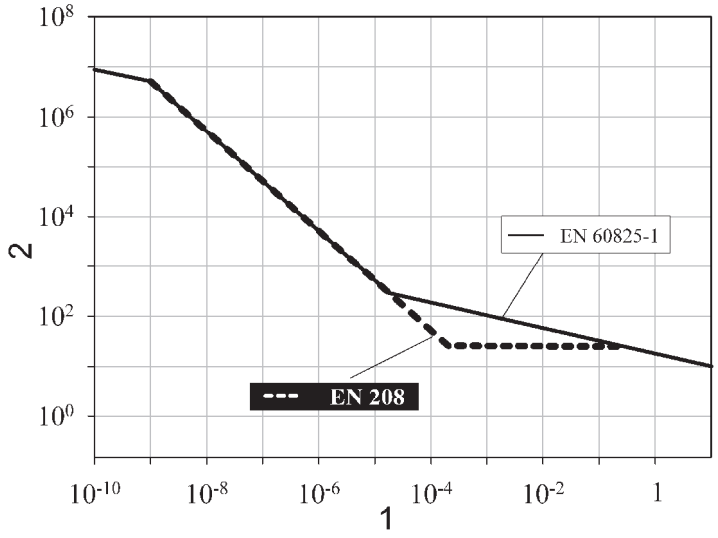
Class 2 lasers are not intrinsically safe but eye-protection is normally afforded by active aversion responses.

A.2 Beam reduction and time base

It is the function of the laser adjustment eye-protectors to reduce the power in the laser beam to class 2 values. In this way, the eye is protected for periods of up to 0,25 s. Active aversion responses should be carried out if glare is noticed during the work with class 2 laser radiation.

A.3 Resistance to laser radiation

A beam diameter of approximately 1 mm has been used as the basis for the requirement of resistance to laser radiation as many typical lasers in the visible spectral range (e.g. argon lasers, He-Ne lasers, krypton lasers) are in this diameter range.



Key

1 exposure duration (s)

2 irradiance (W/m^2)

Figure A.1 — Comparison of the limit values of EN 60825-1:2007 with the simplified values of this European Standard

A.4 Example test report

The report for the test of resistance to laser radiation should contain at least the following information.

Table A.1 — Test report

Laser specifications	**Laser parameter**		**Symbol**	**Unit**	**Value**
	Wavelength		λ		
	Average power range		P_m		
	Pulse frequency range		F		
	Pulse energy		Q_{pulse}		
	Peak power		P_{peak}		
	Optical pulse duration		T_{pulse}		
	Beam diameter at beam exit		$D_{86,5}$		
	Beam quality		M^2		
	Beam divergence (full angle)		Θ		
	Beam polarisation		-		
Laser beam diagnostics and detection equipment	**Measuring devices**		**Type**		**Manufacturer**
	Power measurement				
	Energy measurement				
	Beam analyser				
	Transmission measurement				
Report No.			**Date**		
Sample No.			**Operator**		
Test conditions				**Observations**	
Scale number	RB, CW		-	**During irradiation:**	
Required power density	E		W/m^2		
Beam diameter at sample surface	d_{63}		mm	**Laser side:**	
Irradiated area	A_{63}		m^2		
Pulse duration	cw	-	-	**Eye side:**	
Average power measured externally	P		W		
Measured scale number	-		*RB	**Transmittance:**	
Test duration	T_{test}		s		

Table A.1 *(continued)*

Scale number	RB, pulsed		-	**During irradiation:**
Required energy density	H		J/m^2	
Beam diameter at sample surface	D_{63}		mm	**Laser side:**
Irradiated area	A_{63}		m^2	
Pulse duration	t_{pulse}		s	**Eye side:**
Repetition rate	F		Hz	
Average power measured externally	P_m		W	
Measured scale number	-		*RB	**Transmittance:**
Testing time	t_{test}		s	

Arrangement drawing of the testing set-up	
Comments	

Annex B
(informative)

Recommended use of laser adjustment eye-protectors

B.1 General

This annex gives recommendations for the selection of laser radiation eye-protectors. Before selecting eye protection a risk assessment should be undertaken and the risk minimised by engineering and administrative controls. Control methods are outlined in EN 60825-1 and applicable national regulations and guidance.

Eye-protectors specified in this European Standard are used for adjustment work on lasers in a visible spectral range 400 nm to 700 nm where the path of the beam has to be seen. Eye-protectors specified in EN 207 generally do not allow this. However, eye-protectors specified in this European Standard are not suitable for looking directly into the laser beam. For better protection against hazards of this type, eye-protectors meeting the requirements of EN 207 should be used.

When eye-protectors as specified in this European Standard are used, the eye is only protected against damage from an accidental direct look at the beam − as in the case of class 2 lasers (1 mW for continuous wave lasers, see also A.1) if the period of irradiation is limited to 0,25 s. In the event of longer exposure to the beam, the filters described in EN 207 shall be used.

The period of 0,25 s is short for performing active aversion response and investigations on the blink reflex show that it takes effect only on approximately 20 % of the tested persons. Therefore an enhanced period of time may be recommended to allow for active aversion response reaction in case of being exposed to glare by the laser beam. The reduced values of power and energy in the third and fifth column of Table B.1 result in a reaction time of approximately 2 s.

B.2 Continuous wave lasers

Table B.1, column 2, summarizes the use, in conformity with the requirements, of laser adjustment eye-protectors in continuous wave lasers. The reduced values of laser power in column 3 allows for an enhanced period of time to actively perform aversion responses. The power and energy values given relate to the maximum laser beam diameter of 7 mm. If the laser beam is considerably larger, then the selection can be based on the fraction of the power that would pass through a 7 mm aperture.

Table B.1 — Application of laser adjustment eye-protectors

Scale number	Maximum instantaneous laser power for continuous wave lasers for emission durations $\geq 2 \times 10^{-4}$ s Time basis 0,25 s	Maximum instantaneous laser power for continuous wave lasers for emission durations $\geq 2 \times 10^{-4}$ s Reaction time 2 s	Maximum laser energy for pulsed lasers for pulse durations from 10^{-9} s to $< 2 \times 10^{-4}$ s Time basis 0,25 s	Maximum laser energy for pulsed lasers for pulse durations from 10^{-9} s to $< 2 \times 10^{-4}$ s Reaction time 2 s
	W	W	J	J
RB 1	0,01	0,006	2×10^{-6}	$1,2 \times 10^{-6}$
RB 2	0,1	0,06	2×10^{-5}	$1,2 \times 10^{-5}$
RB 3	1	0,6	2×10^{-4}	$1,2 \times 10^{-4}$
RB 4	10	6	2×10^{-3}	$1,2 \times 10^{-3}$
RB 5	100	60	2×10^{-2}	$1,2 \times 10^{-2}$

The use of a laser adjustment eye-protector of a higher scale number than is necessary according to Table B.1 reduces the brightness of the images of the laser spot used in adjustment work. It is therefore recommended that this table be used with discretion when selecting laser adjustment eye-protectors.

B.3 Pulsed lasers

B.3.1 General

For pulsed and quasi-continuous lasers, EN 60825-1:2007 requires that the class 1 limiting values are adhered to for periods < 0,25 s (see also A.1). Table B.1, column 4 summarizes the use in conformity with the requirements, of laser adjustment eye-protectors for pulsed lasers with a pulse duration greater than 2×10^{-4} s. The reduced values of laser energy in column 5 allows for an enhanced period of time to actively perform aversion responses.

B.3.2 Slow pulse series (frequency < 0,1 s^{-1})

For the slow pulse sequences and pulse durations between 10^{-9} and 2×10^{-4} s, the filters given by column 4 of Table B.1 can be selected.

B.3.3 Fast pulse series (frequency > 0,1 s^{-1})

The exposure from any single pulse within a pulse train shall not exceed the permissible exposure for a single pulse reduced by a correction factor. This is accounted for by multiplying the single pulse energy Q by a factor k.

$$k = N^{1/4} \tag{B.1}$$

where

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

Remark at the calculation of the factor *k*:

If ν *is* the pulse repetition frequency of the laser, then the total number *N* of pulses for the exposure duration is calculated by:

$$N = \nu \times T = \nu \times 5\ s \qquad \text{(B.2)}$$

The correction factor is then given by (B.1).

The relation (B.2) shall only be applied if the time separation between consecutive single pulses $\delta T = 1/\nu$ is longer than the period T_i as given by Table B.2. For pulse intervals shorter than T_i the energy of all pulses appearing during T_i shall be added. The maximum repetition frequency to be applied ν_{max} is then the inverse of the time T_i. In this case the correction factor for the energy density of the single laser pulse is given by the product of *k* and an additional factor k_{Ti}, which accounts for the number of pulses in the time T_i.

Table B.2 — Period of time T_i below which impulse energies of single pulses have to be added and maximum pulse repetition frequencies $\nu_{max} = 1/T_i$ for the application of (B.2)

Wavelength nm	**T_i** s	**ν_{max}** Hz
$400 \leq \lambda < 700$	18×10^{-6}	$55{,}56 \times 10^{3}$

The evaluation procedure for the required scale number is the following:

The pulse energy *Q* of the laser beam is multiplied by *k* or, if Table B.2 applies, by $k \times k_{Ti}$ to deliver Q'. Then, for Q', the necessary scale number is taken from column 4 of Table B.1.

Annex C
(informative)

Significant technical changes between this European Standard and the previous edition

Clause, paragraph, table, figure	Change
Table 1, Table 2, Clause 6 and Table B.1	The scale number is preceded by the letters RB in order to distinct between the old and new standards.
3.3	Correction factor $N^{-1/4}$ for the energy densities in Table 1 was introduced.
3.10.1	A clause was added which allows interchangeable filters, if the frame does not contribute to laser safety.
A.4	A sample test report was added.
NOTE This table refers to the most significant changes since the previous editions, the list is not exhaustive.	

Annex ZA
(informative)

Relationship between this European Standard and the Essential Requirements of EU Directive 89/686/EEC

This European Standard has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association to provide a means of conforming to Essential Requirements of the New Approach Directive 89/686/EEC.

Once this standard is cited in the Official Journal of the European Union under that Directive and has been implemented as a national standard in at least one Member State, compliance with the clauses of this standard given in Table ZA.1 confers, within the limits of the scope of this standard, a presumption of conformity with the corresponding Essential Requirements of that Directive and associated EFTA regulations.

Table ZA.1 — Correspondence between this European Standard and Directive 89/686/EEC

Clause(s)/subclause(s) of this EN	Essential Requirements (ERs) of Directive 89/686/EEC	Qualifying remarks/Notes
3.7, 3.9, 3.10	1.2.1 Absence of risks and other "inherent" nuisance factors	
3.5.1	1.2.1.3 Maximum permissible user impediment	
3.3, 3.6.1, 3.6.2, 3.11.1	1.3.2 Lightness and design strength	
5, 6	1.4 Information supplied by the manufacturer	
3.2, 3.4, 3.5.2, 3.8	2.3 PPE for the face, eyes and respiratory tracts	
6	2.12 PEE bearing one or more identification or recognition marks directly or indirectly relating to health and safety	
3.11.2	3.1.1 Impact caused by falling or projecting objects and collision of parts of the body with an obstacle	
3.1	3.9.1 Non-ionizing radiation	

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

Bibliography

[1] EN 60825-1:2007, *Safety of laser products — Part 1: Equipment classification and requirements (IEC 60825-1:2007)*

[2] Directive 2006/25/EC of the European Parliament and of the Council of 5 April 2006 on the minimum health and safety requirements regarding the exposure of workers to risks arising from physical agents (artificial optical radiation).

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BSI Group
Headquarters 389
Chiswick High Road,
London, W4 4AL, UK
Tel +44 (0)20 8996 9001
Fax +44 (0)20 8996 7001
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