BRITISH STANDARD

BS EN 12254:2010

Screens for laser working places — Safety requirements and testing

ICS 13.280; 31.260

National foreword

This British Standard is the UK implementation of EN 12254:2010. It supersedes BS EN 12254:1998+A2:2008 which is withdrawn.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.

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Abschirmungen an Laserarbeitsplätzen - Sicherheitstechnische Anforderungen und Prüfung

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Foreword

This document (EN 12254:2010) 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of an identical text or by endorsement, at the latest by September 2010, and conflicting national standards shall be withdrawn at the latest by September 2010.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 12254:1998+A2:2008.

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 EC Directive(s).

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

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, Croatia, 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 specifies functional requirements and a product labelling applicable to temporary and permanent passive guards (in the following called screens) for protection against laser radiation. This standard includes test methods for testing functional performance and the specification of the user documentation to be supplied with the product. The screens are designed to protect the user from:

— unintentional exposure to direct and/or diffuse laser radiation;

— a time limited exposure to laser radiation, based on the functional requirements determined by risk assessment.

This European Standard applies to supervised screens for installations in working places at which laser radiation up to a maximum mean power of 100 W or single pulse energy of 30 J occurs within the spectral range between 180 nm (0,18 µm) and 10^6 nm (1 000 µm).

This European Standard applies to the protection against laser radiation only. This standard does not apply to other hazards including hazards from secondary radiation that can arise during, for example, material processing.

This European Standard gives guidance on how to select such screens.

Laser enclosures and housings that are supplied as part of the laser product or are supplied to be fitted to a laser system to form a laser product (according to EN 60825-1) are not considered to be within the scope of the standard.

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 165:2005, *Personal eye-protection — Vocabulary*

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

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

EN 1598:1997, *Health and safety in welding and allied processes — Transparent welding curtains, strips and screens for arc welding processes*

EN 1598:1997/A1:2001, *Health and safety in welding and allied processes — Transparent welding curtains, strips and screens for arc welding processes*

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

EN 60825-4:2006, *Safety of laser products — Part 4: Laser guards (IEC 60825-4:2006)*

IEC 60050-845:1987, *International Electrotechnical Vocabulary — Chapter 845: Lighting*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 165:2005, EN 60825-1:2007, EN 60825-4:2006 and IEC 60050-845:1987 apply.

4 Requirements

4.1 Spectral transmittance

The relationship between spectral transmittance at the laser wavelength and resistance to laser radiation is based on the maximum permissible exposure (MPE) shown in EN 60825-1. To simplify product specification, tests are conducted for laser test conditions described in Table 1. The laser test conditions are referred to by the symbols D, I, R and M.

Table 1 — Duration of test applicable to screens for laser working places

Test condition (corresponding laser designation)	Pulse duration s	Number of pulses
D (continuous wave (CW) laser)	100	1
I (pulsed laser)	10^{-6} to 10^{-2}	1 000
R (Giant pulsed laser)	10^{-9} to 10^{-6}	1 000
M (Mode-coupled pulsed laser)	$\leq 10^{-9}$	100 000
NOTE The listed pulse durations are values of typical lasers. A laser with a pulse length in this range of values is recommended for testing. Total exposure time for each test should be about 100 s.		

4.2 Resistance to laser radiation

The screens shall not lose their protective properties and shall stay within the scale number under effect of laser radiation with the power and energy density as specified in Table 2 including induced transmission (reversible bleaching).

4.3 Stability to UV radiation

When exposed to ultraviolet radiation in accordance with 5.4.1, the spectral transmittance at the laser wavelengths shall not exceed the maximum permissible spectral transmittance of the corresponding scale number.

4.4 Stability to elevated temperature

After exposure to elevated temperature in accordance with 5.4.2, the requirements of 4.1 to 4.2 shall be met.

4.5 Mechanical strength

Flexible screens shall withstand for 10 s a tensile stress of 15 N/mm^2 when tested according to 5.5.1. After this test, no sample shall be torn.

Inflexible screens shall be robust in accordance to 7.1.4.2 of EN 166:2001.

Fixing systems of screens shall be designed so that they remain attached to the screens or to the machinery when the screens are removed.

4.6 Resistance to ignition

Flexible screens shall satisfy the requirements of 4.4 of EN 1598:1997 when tested in accordance with 4.4 of EN 1598:1997 and EN 1598:1997/A1:2001.

Inflexible screens shall meet requirements according to 7.1.7 of EN 166:2001.

5 Testing

5.1 General

The testing schedule in Table 3 applies to testing of flexible and inflexible screens. At least 18 samples are required for testing. If testing for several wavelengths (wavelength ranges) or testing conditions according to Tables 1 and 3 has to be done, more samples can be necessary.

5.2 Spectral transmittance

The spectral transmittance shall be determined at normal incidence. Screens with angular-dependent transmittance shall be measured at angles of incidence between 0° and 90° with polarised radiation. In this case, the scale number results from the highest of the spectral transmittance values measured.

5.3 Resistance to laser radiation

Testing shall be carried out with laser radiation of the specific wavelength(s) and the power and energy densities as indicated in Table 2. Spectral transmittance at the laser wavelength shall be measured during the exposure to laser radiation.

Table 2 — Scale numbers of screens for laser working places (maximum spectral transmittance and resistance to laser radiation)

Scale number	Maximum spectral transmittance at the laser wavelength $\tau(\lambda)$	Mean power (E) and single pulse energy density (H) for testing protective properties and resistance to laser radiation in the wavelength range									
		180 nm to 315 nm			> 315 nm to 1 050 nm	> 1 050 nm to 1 400 nm	> 315 nm to 1 400 nm		> 1 400 nm to 10^6 nm		
		For test condition/pulse duration in s (see Table 1)									
		D	I, R	M	D	D	I, R	M	D	I, R	M
		> 0,25	> 10^{-9} to 0,25	≤ 10^{-9}	> $5{\cdot}10^{-3}$	> $2{\cdot}10^{-3}$	> 10^{-9} to 0,01	≤ 10^{-9}	> 0,1	> 10^{-9} to 0,1	≤ 10^{-9}
		E_D W/m^2	$H_{I,R}$ J/m^2	E_M W/m^2	E_D W/m^2	E_D W/m^2	$H_{I,R}$ J/m^2	H_M J/m^2	E_D W/m^2	$H_{I,R}$ J/m^2	E_M W/m^2
AB1	10^{-1}	0,01	$3{\cdot}10^{2}$	$3{\cdot}10^{11}$	10	$2{,}5{\cdot}10^{2}$	0,05	0,0015	10^{4}	10^{3}	10^{12}
AB2	10^{-2}	0,1	$3{\cdot}10^{3}$	$3{\cdot}10^{12}$	10^{2}	$2{,}5{\cdot}10^{3}$	0,5	0,015	10^{5}	10^{4}	10^{13}
AB3	10^{-3}	1	$3{\cdot}10^{4}$	$3{\cdot}10^{13}$	10^{3}	$2{,}5{\cdot}10^{4}$	5	0,15	10^{6}	10^{5}	10^{14}
AB4	10^{-4}	10	$3{\cdot}10^{5}$	$3{\cdot}10^{14}$	10^{4}	$2{,}5{\cdot}10^{5}$	50	1,5	10^{7}	10^{6}	10^{15}
AB5	10^{-5}	10^{2}	$3{\cdot}10^{6}$	$3{\cdot}10^{15}$	10^{5}	$2{,}5{\cdot}10^{6}$	$5{\cdot}10^{2}$	15	10^{8}	10^{7}	10^{16}
AB6	10^{-6}	10^{3}	$3{\cdot}10^{7}$	$3{\cdot}10^{16}$	10^{6}	$2{,}5{\cdot}10^{7}$	$5{\cdot}10^{3}$	$1{,}5{\cdot}10^{2}$	10^{9}	10^{8}	10^{17}
AB7	10^{-7}	10^{4}	$3{\cdot}10^{8}$	$3{\cdot}10^{17}$	10^{7}	$2{,}5{\cdot}10^{8}$	$5{\cdot}10^{4}$	$1{,}5{\cdot}10^{3}$	10^{10}	10^{9}	10^{18}
AB8	10^{-8}	10^{5}	$3{\cdot}10^{9}$	$3{\cdot}10^{18}$	10^{8}	$2{,}5{\cdot}10^{9}$	$5{\cdot}10^{5}$	$1{,}5{\cdot}10^{4}$	10^{11}	10^{10}	10^{19}
AB9	10^{-9}	10^{6}	$3{\cdot}10^{10}$	$3{\cdot}10^{19}$	10^{9}	$2{,}5{\cdot}10^{10}$	$5{\cdot}10^{6}$	$1{,}5{\cdot}10^{5}$	10^{12}	10^{11}	10^{20}
AB10	10^{-10}	10^{7}	$3{\cdot}10^{11}$	$3{\cdot}10^{20}$	10^{10}	$2{,}5{\cdot}10^{11}$	$5{\cdot}10^{7}$	$1{,}5{\cdot}10^{6}$	10^{13}	10^{12}	10^{21}

The values of energy density (H) in Table 2 for testing the resistance against laser radiation for pulsed lasers (I, R, M) should be multiplied with the factor $N^{-1/4}$, where N is the number of pulses in 100 s.

For pulsed lasers, testing should be done with low repetition rates (≤ 25 Hz). If not possible, the energy density used for testing shall be given and the product shall be marked in accordance with Clause 6.

The diameter d_{63} of the laser beam during this test shall be (1 ± 0,1) mm. The testing period is indicated in Table 1.

For pulse durations < 1 ns the diameter d_{63} of the laser beam during this test shall be ≥ 0,5 mm.

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 screens for laser radiation workplaces shall be tested in accordance with the test condition D. If commercially available, testing at mode D shall be done with a real cw laser. If it is not feasible, testing shall be done with a pulsed laser system at a minimum pulse repetition frequency of $f \geq 25$ Hz. If no laser with pulse repetition rates higher than 25 Hz is available, a pulsed laser system at a minimum pulse repetition frequency of $\nu \geq 5$ Hz may be used to test condition D.

If additional protection against pulsed lasers is required, the screens shall be tested according to one or several of the test conditions I, R or M.

Only lasers that do not show spiking at the beginning of the emission shall be used. The spatial and temporal beam profile shall be documented, except for temporal profile of M mode lasers.

Table 3 — Test schedule for screens for protection against laser radiation

Order of testing	Requirement	According to Clause	Number of screen samples				
			3	3	6	3	3 or more
1	Marking	6	+	+	+	+	+
2	Spectral transmittance at laser wavelength λ	4.1	+	+			3 samples per λ and test condition
3	Stability to UV radiation	4.3		+			
4	Stability to elevated temperature	4.4	+				
5	Spectral transmittance at laser wavelength λ	4.3, 4.4	+	+			
6	Mechanical strength	4.5			+		+
7	Resistance to laser radiation and spectral transmittance at laser wavelength λ	4.2					3 samples per λ and test condition
8	Resistance to ignition	4.6				+	

5.4 Stability to UV radiation and stability at elevated temperature

5.4.1 Stability to UV radiation

Testing shall be done according to Clause 6 of EN 168:2001 with an exposure time of (50 ± 0,2) h.

5.4.2 Stability at elevated temperature

Screens 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 (23 ± 5) °C.

5.5 Mechanical strength

5.5.1 Flexible screens

5.5.1.1 Testing machine

The tensile testing machine shall be power-driven and capable of maintaining the appropriate rate of grip separation as specified in 5.5.1.3. The testing machine shall be equipped with the following devices.

— Grips for holding the test sample, one being fixed and the other movable.

The grips shall be self-aligning in that they are attached to the machine in such a way that they move freely into alignment as soon as any load is applied so that the long axis of the test sample coincides with the direction of pull through the centre line of the grip assembly. The test sample shall be held in such a way that slip relative to the grip is prevented as far as possible and this shall preferably be effected with the type of grip which maintains or increases pressure on the test sample as the force applied to the test sample increases. The clamping system shall not cause premature fracture at the grips.

— Load indicator incorporating a suitable load-indicating mechanism capable of showing the total tensile load carried by the test sample when held by the grips.

5.5.1.2 Test samples

Test samples 7 to 9 (10 mm wide and 150 mm long) are cut from the screen.

Test samples 10 to 12 (10 mm wide and 150 mm long) are cut from the screen, the longer dimension being perpendicular to the longer dimension of samples 7 to 9 when cutting them from the screen.

Determine the mean width and mean thickness of the test samples.

Gauge marks (50,0 ± 0,5) mm apart shall be marked on the centre portion of the test samples using ink or other medium that does not affect the material being tested. Gauge marks shall not be punched, scratched or impressed upon the test samples.

Before testing for resistance to tear, the 6 samples shall be tested according to 5.4 for resistance to UV radiation. During this testing, at least the zone between the gauge marks shall be irradiated.

5.5.1.3 Procedure

Mount the test sample in the grips of the testing machine so that the axial alignment coincides with the direction of pull. Tighten the grips uniformly and firmly to prevent the sample from slipping, but not to the extent that the test sample is damaged.

Clamp the test sample so that the distance between the grips of the testing machine is (100 ± 1) mm and the gauge marks are centrally disposed between the grips.

Separate the grips of the testing machine with a speed of (250 ± 25) mm/min until a tensile stress of (15,0 ± 1,5) N/mm^2 is reached. 10 s after the maximum tensile stress has been reached, it is noted if any of the samples did tear.

Some materials have a very high elongation, which may bring them outside the stretching capacity of the testing machine. In such cases, it is permissible to reduce the initial distance between the grips to (50 ± 0,5) mm. The test with reduced distance shall be performed with a new sample.

5.5.2 Inflexible screens

Robustness shall be tested according to 3.1 of EN 168:2001.

5.5.3 Resistance to ignition

Testing of flexible screens shall be done in accordance with EN 1598:1997 and EN 1598:1997/A1:2001.

Testing of inflexible screens shall be done in accordance with Clause 7 of EN 168:2001.

6 Marking

Screens in accordance with this standard shall be permanently marked. The height of letters shall be at least 10 mm.

The rear side of the screen (not to be exposed to laser radiation) shall be clearly identified if the orientation of the screen is important.

Each part of a screen installation shall be marked.

The screen shall be marked as follows with the symbols for the laser test conditions (see Table 1) for which they provide protection:

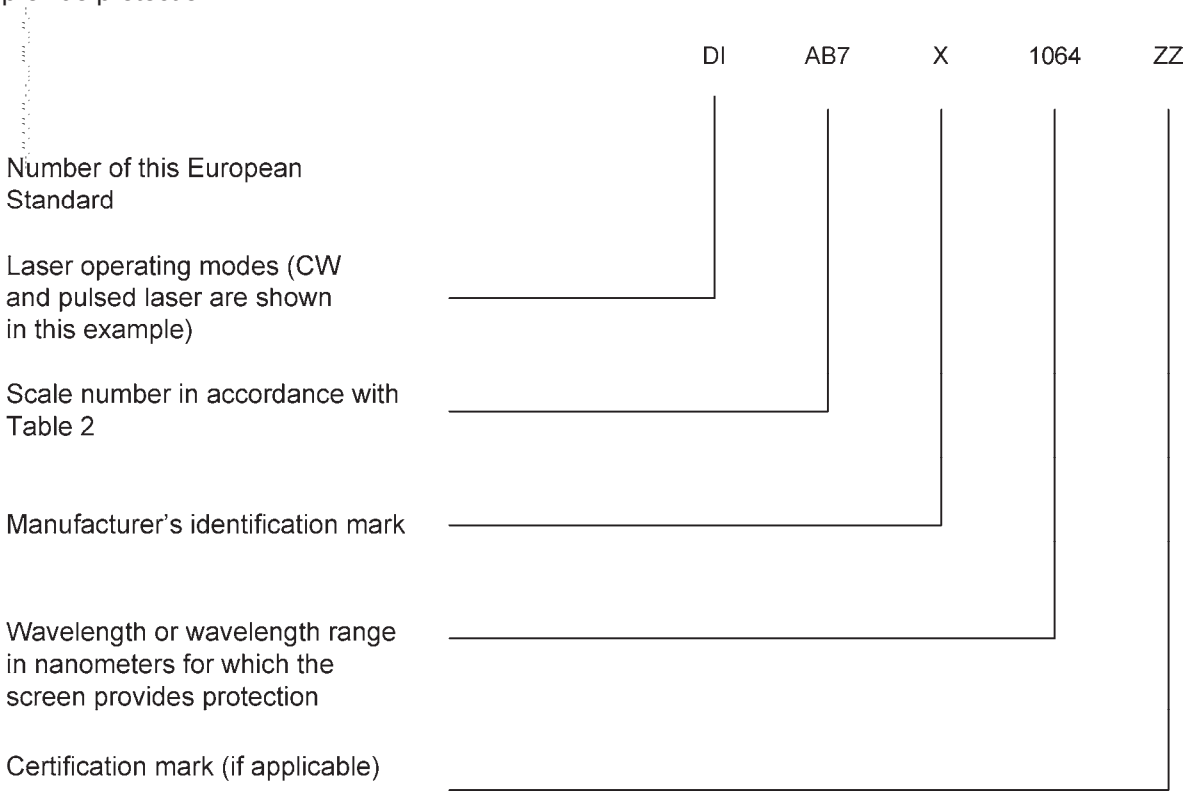


Figure 1 – Example for the marking of screens for protection against laser radiation

If not tested with low repetition rates (≤ 25 Hz), the suffix Y shall be added to the scale number, e.g. R AB7Y.

If the screen provides protection in a wavelength range, the latter shall be marked in nanometres as given in the following example for the range 180 nm to 315 nm: 180 - 315.

The manufacturer identification mark may consist of one or more letters or symbols.

7 Information supplied by the manufacturer

National legislation can define minimum requirements for information. At least the following information shall be supplied by the manufacturer or supplier in the national language(s) of the country to which the screen is sold:

a) Name and address of the manufacturer or supplier;

b) An explanation of the marking;

c) Description of the method of mounting and fixing of the screen;

d) Maintenance requirements, including e.g. details of inspection; details regarding appropriate cleaning, e.g. cleaning solutions, disinfectants and procedures which may be used;

e) A note that damaged screens should not be used;

f) In the case of screens with reflecting surfaces, or mirror layers a note that dust or splashes on the screen surface can reduce the resistance against laser radiation of the screen;

g) A note that in cases where the working process is to be observed, dazzling light may occur at the laser working place caused by high luminance, especially during laser welding. This note should include the recommendation to use a welding filter with appropriate scale number according to EN 169 in addition to transparent screens to avoid glare;

h) The laser parameters for which the resistance to laser radiation of the screen was tested;

i) A note that before selecting an appropriate screen, a risk assessment to determine the maximum reasonably foreseeable exposure should be performed (see e.g. Annex B of EN 60825-4:2006);

j) A note that this assessment should be based on the power/energy density averaged over a circular area not more than 1,13 mm diameter;

k) A note that the recommendations for the use of screens at laser working places are based on the assumption of regular inspection the period of which is dependent on a risk assessment.

Annex A
(informative)

Principles

A.1 Limit values

The maximum permissible exposure (MPE) to radiation for eye and skin is specified in EN 60825-1. These limit values show a complicated dependency on time and wavelengths. For this reason, a simplified set of values is used in this standard, which either agree or are conservative compared with MPE. These simplified values are listed in Table A.1. Figure A.1 gives a comparison of the values of EN 60825-1:2007 and Table A.1.

Table A.1 — Simplified maximum permissible exposure (MPE) values for the cornea of the eye

Wavelength range nm	**Pulse duration** s	**Power density** *E* W/m^2	**Pulse duration** s	**Power density** *H* J/m^2	**Pulse duration** s	**Power density** *E* W/m^2
180 – 315	$< 10^{-9}$	3×10^{10}	10^{-9} – 30 000	30	30 000 (average value)	10^{-3}
> 315 – 1 050	$< 10^{-9}$	5×10^{6}	$10^{-9} – 5 \times 10^{-3}$	0,005	$> 5 \times 10^{-3} – 100$	1
> 1 050 – 1 400	$< 10^{-9}$	5×10^{7}	$10^{-9} – 2 \times 10^{-3}$	0,05	$> 2 \times 10^{-3} – 100$	25
> 1 400 – 10^6	$< 10^{-9}$	10^{11}	10^{-9} – 0,1	100	> 0,1 – 100	1 000

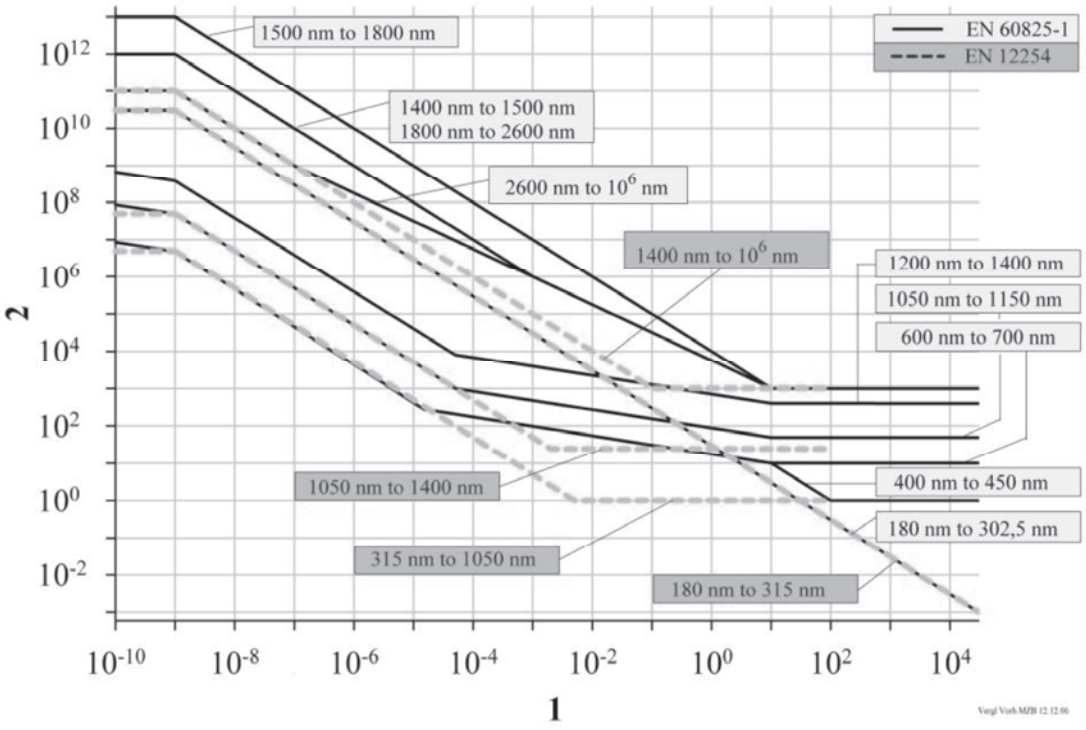
For repetitively pulsed lasers see EN 60825-1:2007 and Annex B.2.

A.2 Time base used to calculate the MPE values

The transmittance requirements of the screens are based on the MPEs valid for 100 s except the spectral range from 180 nm to 315 nm where they are based on the MPEs valid for 30 000 s.

A.3 Resistance to laser radiation

The resistance to laser radiation of the screens is tested during 100 s with continuous wave lasers and a typically equivalent period for pulsed lasers (see Table 1).



Key

1 Exposure duration [s]

2 Irradiance [W/m²]

Figure A.1 — Comparison of the MPE values of EN 60825-1:2007 with the values in Table A.1

A.4 Example test report

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

Table A.2 — 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	D AB		-	**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	-		*D AB	**Transmittance:**	
Test duration	T_{test}		s		

Table A.2 (*continued*)

Scale number	I R M AB		-	**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	-		* I R AB	**Transmittance:**
Testing time	t_{test}		s	

Arrangement drawing of the testing set-up	
Comments	

Annex B
(informative)

Selection of screens for laser working places

B.1 General

Before selecting an appropriate screen, a risk assessment to determine the maximum reasonably foreseeable exposure should be performed (see e.g. Annex B of EN 60825-4:2006).

This assessment should be based on the power/energy density averaged over a circular area of not more than 1,13 mm diameter (1 mm^2).

If this beam diameter or other beam diameters *d* than 1 mm (diameter to test resistance to laser radiation) are used to determine the scale number of an appropriate screen, power and energy densities of Table B.1 should be multiplied by the following functions (*d* is the beam diameter in mm) depending on the main constituent of the screen:

— Glass $F(d) = d^{1,1693}$

— Plastic $F(d) = d^{1,2233}$

NOTE Due to heat dissipation, the resistance to laser radiation depends not only on the power and energy density, but also on the diameter of the irradiated area.

The following recommendations for the use of screens at laser working places are based on the assumption of regular inspection the period of which is dependent on a risk assessment.

The selection of screens is indicated in Table B.1, the significance of the symbols D, I, R and M is given in Table B.2.

B.2 Pulsed lasers

For pulsed lasers emitting at wavelengths equal to or greater than 400 nm, the total number *N* of the pulses within 100 s should be determined.

After calculating the energy density *H* of the individual pulse it should be multiplied by $N^{1/4}$ ($H' = H \times N^{1/4}$). Thus with the resulting value *H'* the required scale number can be read from Table B.1.

For pulsed lasers emitting at wavelengths below 400 nm, the single pulse energy density should be used for the selection of the screen.

These rules are based on EN 60825-1:2007.

In addition, the average power should be calculated for all pulse sequences and compared with the values of the corresponding column marked D in Table B.1. If this results in a higher scale number, the higher one shall be used, or at least a screen should be used with individually specified scale numbers for pulsed mode (I, R or M) and continuous wave mode D.

Table B.1 – Scale numbers and use of the screens for protection against accidental irradiation

Scale number	Maximum spectral transmittance at the laser wavelength $\tau(\lambda)$	Mean power (*E*) and single pulse energy density (*H*) for testing protective properties and resistance to laser radiation in the wavelength range									
		180 nm to 315 nm			> 315 nm to 1 050 nm	> 1 050 nm to 1 400 nm	> 315 nm to 1 400 nm		> 1 400 nm to 10^6 nm		
		For test condition/pulse duration in s (see Table 1)									
		D	I, R	M	D	D	I, R	M	D	I, R	M
		> 0,25	> 10^{-9} to 0,25	≤ 10^{-9}	> $5{\cdot}10^{-3}$	> $2{\cdot}10^{-3}$	> 10^{-9} to 0,01	≤ 10^{-9}	> 0,1	> 10^{-9} to 0,1	≤ 10^{-9}
		E_D W/m^2	$H_{I,R}$ J/m^2	E_M W/m^2	E_D W/m^2	E_D W/m^2	$H_{I,R}$ J/m^2	H_M J/m^2	E_D W/m^2	$H_{I,R}$ J/m^2	E_M W/m^2
AB1	10^{-1}	0,01	$3{\cdot}10^{2}$	$3{\cdot}10^{11}$	10	$2{,}5{\cdot}10^{2}$	0,05	0,0015	10^{4}	10^{3}	10^{12}
AB2	10^{-2}	0,1	$3{\cdot}10^{3}$	$3{\cdot}10^{12}$	10^{2}	$2{,}5{\cdot}10^{3}$	0,5	0,015	10^{5}	10^{4}	10^{13}
AB3	10^{-3}	1	$3{\cdot}10^{4}$	$3{\cdot}10^{13}$	10^{3}	$2{,}5{\cdot}10^{4}$	5	0,15	10^{6}	10^{5}	10^{14}
AB4	10^{-4}	10	$3{\cdot}10^{5}$	$3{\cdot}10^{14}$	10^{4}	$2{,}5{\cdot}10^{5}$	50	1,5	10^{7}	10^{6}	10^{15}
AB5	10^{-5}	10^{2}	$3{\cdot}10^{6}$	$3{\cdot}10^{15}$	10^{5}	$2{,}5{\cdot}10^{6}$	$5{\cdot}10^{2}$	15	10^{8}	10^{7}	10^{16}
AB6	10^{-6}	10^{3}	$3{\cdot}10^{7}$	$3{\cdot}10^{16}$	10^{6}	$2{,}5{\cdot}10^{7}$	$5{\cdot}10^{3}$	$1{,}5{\cdot}10^{2}$	10^{9}	10^{8}	10^{17}
AB7	10^{-7}	10^{4}	$3{\cdot}10^{8}$	$3{\cdot}10^{17}$	10^{7}	$2{,}5{\cdot}10^{8}$	$5{\cdot}10^{4}$	$1{,}5{\cdot}10^{3}$	10^{10}	10^{9}	10^{18}
AB8	10^{-8}	10^{5}	$3{\cdot}10^{9}$	$3{\cdot}10^{18}$	10^{8}	$2{,}5{\cdot}10^{9}$	$5{\cdot}10^{5}$	$1{,}5{\cdot}10^{4}$	10^{11}	10^{10}	10^{19}
AB9	10^{-9}	10^{6}	$3{\cdot}10^{10}$	$3{\cdot}10^{19}$	10^{9}	$2{,}5{\cdot}10^{10}$	$5{\cdot}10^{6}$	$1{,}5{\cdot}10^{5}$	10^{12}	10^{11}	10^{20}
AB10	10^{-10}	10^{7}	$3{\cdot}10^{11}$	$3{\cdot}10^{20}$	10^{10}	$2{,}5{\cdot}10^{11}$	$5{\cdot}10^{7}$	$1{,}5{\cdot}10^{6}$	10^{13}	10^{12}	10^{21}

NOTE The numbers in this table are the same as in Table 2.

B.3 Caution for users of laser safety screens

The test for resistance to laser radiation stipulated in this standard provides an indication of suitability. The protection afforded by a screen depends on several factors, including laser power, beam area, repetition rate, irradiance distribution, exposure duration and condition of surface. Users should satisfy themselves that the screen material provides adequate protection under the worst reasonably foreseeable conditions of exposure.

Table B.2 — Key to symbols D, I, R and 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}

Annex C
(informative)

Significant technical changes between this European Standard and the previous edition

Clause, paragraph, table, figure	Change
Table 2, Clause 6 and Table B.1	The scale number is preceded by the letters AB in order to distinct between the old and new standards.
4.4	Correction factor $N^{-1/4}$ for the energy densities in Table 2 was introduced.
4.3	The laser beam diameter for testing was set to 1 mm, the minimum repetition frequency for quasi-cw lasers for testing mode was set to 25 Hz and a clause was added that spiking lasers are not admitted for testing. Also the factor f depending on the beam diameter was moved to Annex B.1.
5.1	The potential use of reflective filters and their dependence on the angle of incidence was considered.
A.4	A sample test report was added.
NOTE The technical changes referred include the significant technical changes from the EN revised, but is not a exhaustive list of all modifications from the previous version.	

Annex ZA
(informative)

Relationship between this European Standard and the Essential Requirements of EU Directive 2006/42/EC

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 2006/42/EC on machinery.

Once this standard is cited in the Official Journal of the European Communities under that Directive and has been implemented as a national standard in at least one Member State, compliance with the normative clauses of this standard confers, within the limits of the scope of this standard, a presumption of conformity with Essential Requirements Annex I, Clause 1.5.12 "Laser equipment" of that Directive and associated EFTA regulations.

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

Bibliography

[1] EN 169, *Personal eye-protection — Filters for welding and related techniques — Transmittance requirements and recommended use*

[2] EN ISO 527-3:1995, *Plastics — Determination of tensile properties — Part 3: Test conditions for films and sheets (ISO 527-3:1995)*

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