

Australian/New Zealand Standard™

Eye and face protection

Part 4: Filters and eye protectors against laser radiation (laser eye- protectors)

- A1 | *AS/NZS 1337.4:2011, Eye and face protection, Part 4: Filters and eye protectors against laser radiation (laser eye-protectors), is an identical adoption of EN 207:2009, Personal eye-protection equipment – Filters and eye-protectors against laser radiation (laser eye-protectors), and is reproduced with the permission of CEN, Avenue Marnix 17, B-1000 Brussels, Belgium. All exploitation rights of the European Standards in any form and by any means are reserved world-wide to CEN and its National Members, and no reproduction may be undertaken without express permission in writing by CEN through Standards Australia Limited.*



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Part 4: Filters and eye protectors against laser radiation (laser eye- protectors)

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PREFACE

This Standard was prepared by the Joint Standards Australia/Standards New Zealand Committee SF-006, Eye and Face Protection, to supersede AS/NZS 1337.4:2004, *Personal eye-protection, Part 4: Filters and eye-protectors against laser radiation (laser eye-protectors)*.

This Standard incorporates Amendment No. 1 (December 2014). The changes required by the Amendment are indicated in the text by a marginal bar and amendment number against the clause, note, table, figure or part thereof affected.

The objective of this Standard is to specify performance requirements, test methods, marking requirements, selection and use of personal eye-protectors against laser radiation in the spectral range 180 nm to 1000 micrometre.

This Standard is identical with, and has been reproduced from EN 207:2009, *Personal eye-protection equipment—Filters and eye-protectors against laser radiation (laser eye-protectors)*.

As this Standard is reproduced from a European Standard, the following applies:

- (a) Its number appears on the cover and title page while the European Standard number appears only on the cover.
- (b) In the source text ‘this European Standard’ should read ‘this Australian/New Zealand Standard’.
- (c) A full point substitutes for a comma when referring to a decimal marker.

The term ‘informative’ has been used in this Standard to define the application of the annex to which it applies. An ‘informative’ annex is only for information and guidance.

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AUSTRALIAN/NEW ZEALAND STANDARD

Eye and face protection**Part 4:****Filters and eye protectors against laser radiation (laser eye-protectors)****1 Scope**

This European Standard applies to eye-protectors used for protection against accidental exposure to laser radiation as defined in EN 60825-1:2007 in the spectral range 180 nm (0,18 μm) to 1 000 μm . It defines the requirements, test methods and marking. A guide is given in Annex B for the selection and use of laser eye-protectors.

This European Standard does not apply to protectors for intentional exposure to laser radiation.

EN 208 applies for laser adjustment eye-protectors.

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

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 maximum spectral transmittance at the wavelength(s) or in the wavelength range(s) of protection shall not exceed the values specified in Table 1 for the applicable scale number.

3.2 Luminous transmittance of filters

When assessed 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 % may 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 1 and shall not show any induced transmission (reversible bleaching). No splinters shall come out from the side of the filter facing the eye under the influence of the laser radiation. Any melting or other damage

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of the surface during the course of irradiation is not considered negative if the protective effect is still maintained.

Table 1 — Scale numbers (maximum spectral transmittance and resistance 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 resistance 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		
		For test condition/pulse duration in seconds (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 $< 10^{-9}$
		E_D W/m ²	$H_{I, R}$ J /m ²	E_M 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
LB1	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}
LB2	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}
LB3	10^{-3}	1	3×10^4	3×10^{13}	10^4	5	0,15	10^6	10^5	10^{14}
LB4	10^{-4}	10	3×10^5	3×10^{14}	10^5	50	1,5	10^7	10^6	10^{15}
LB5	10^{-5}	10^2	3×10^6	3×10^{15}	10^6	5×10^2	15	10^8	10^7	10^{16}
LB6	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}
LB7	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}
LB8	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}
LB9	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}
LB10	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}
The symbols D, I, R and M relative to the test conditions are explained in Table 4.										

3.4 Refractive values of filters and eye-protectors

When assessed in accordance with 4.5, the maximum refractive values of filters and eye-protectors with no corrective effect shall be as given in Table 2. The maximum refractive values apply to the range specified in 7.1.2.1 of EN 166:2001.

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

Spherical power m^{-1}	Astigmatic power m^{-1}	Prismatic power difference		
		horizontal		vertical
		base out cm/m	base in cm/m	cm/m
$\pm 0,09$	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 4.6.1.

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 I^* of a filter, determined in accordance with 4.6.2, shall not be greater than

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

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 4.7.1, 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 be $\leq 10\%$:

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

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 exposure to elevated temperature in accordance with 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%:

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

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 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 (see Figure 1).

3.9 Construction of filters and frames

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.

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 this 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.

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 $+90^\circ$ (temporal side) the vertical angle range β is protected within the following limit angles in degrees ($^\circ$).

The upward limit β_u of the protected range shall be:

$$\beta_u = 55 - 0,0013 (\alpha - 12)^2 - 1,3 \times 10^{-6} (\alpha - 12)^4 \quad (4)$$

The downward limit β_l of the protected range shall be:

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

Testing shall be done in accordance with 4.10.

3.10 Mechanical strength of eye-protectors

3.10.1 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.

3.10.2 Optional requirements

If the mechanical strength of filters and eye-protectors against laser radiation is required to satisfy more stringent requirements, the requirements specified in 7.1.4.2 or the requirements specified in 7.2.2 of EN 166:2001 shall be met.

4 Testing

4.1 General

The testing schedule in Table 3 shall be applied to testing of filters, frames and complete eye-protectors. The sequence 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 3 —Test schedule for filters, frames and complete eye-protectors for protection against laser radiation

Order of testing	Requirement	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 and frames	3.9	+	+			
5	Frames	3.9	+	+			
6	Diffusion of 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 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	+				
17	Spectral transmittance	3.1	+	+			
18	Mechanical strength	3.10			+		
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 166:2001	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 1 400 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. 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.

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 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 exposure to laser radiation.

The values of energy density (H) in Table 1 for testing the resistance against laser radiation for pulsed lasers (I, R, M) shall be multiplied with the factor $N^{1/4}$, where N is the number of pulses in 5 s.

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

The diameter d_{63} of the laser beam during this test shall be $(1 \pm 0,1)$ mm.

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

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

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	Minimum number of pulses
D	Continuous wave laser	5	1
I	Pulsed laser	$> 10^{-6}$ to 0,25	50
R	Q switch pulsed laser	$> 10^{-9}$ to 10^{-6}	50
M	Mode-coupled pulse laser	$< 10^{-9}$	50

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.

Testing shall be done at least for 5 s, but in the case of pulsed operation never with less than 50 pulses.