INTERNATIONAL STANDARD

ISO 12609-1

First edition
2013-07-15

Eyewear for protection against intense light sources used on humans and animals for cosmetic and medical applications —

Part 1: Specification for products

Équipements ophtalmiques de protection contre les sources lumineuses intenses utilisées sur les animaux et les humains pour des applications médicales et cosmétiques —

Partie 1: Spécifications des produits

Reference number
ISO 12609-1:2013(E)

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Published in Switzerland

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2. www.iso.org/directives

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Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

The committee responsible for this document is ISO/TC 94, *Personal safety — Protective clothing and equipment*, Subcommittee SC 6, *Eye and face protection*.

ISO 12609 consists of the following parts, under the general title *Eyewear for protection against intense light sources used on humans and animals for cosmetic and medical applications*:

— *Part 1: Specification for products*

— *Part 2: Guidance for use*

Eyewear for protection against intense light sources used on humans and animals for cosmetic and medical applications —

Part 1: Specification for products

1 Scope

This part of ISO 12609 specifies performance and labelling of eye protectors used for ILS equipment used on humans and animals for cosmetic and medical applications against excessive exposure to optical radiation in the spectral range 250 nm to 3 000 nm, with the exception of laser radiation.

This part of ISO 12609 provides a specification for an eye protector expected to cope with the majority of applications. A more rigorous procedure for determining appropriate eye protection against spectral outputs from ILS equipment is described in the annexes.

This part of ISO 12609 is not applicable to eye protectors for use with tanning equipment, ophthalmic instruments or other medical/cosmetic devices, the safety issues of which are addressed through other European and International standards.

2 Normative references

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

ISO 12311:2013, *Personal protective equipment — Test methods for sunglasses and related equipment*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
blue light hazard
potential for a photochemically induced retinal injury resulting from optical radiation exposure in the wavelength range 300 nm to 700 nm

3.2
filter protection factor
FPF
factor by which the filter attenuates the weighted ocular exposure

Note 1 to entry: Mathematical expressions for FPF are given in Annex A and example calculations in Annex B and Annex C.

3.3
infra-red lens hazard
potential for a thermal injury to cornea and lens of the eye resulting from optical radiation exposure in the wavelength range 780 nm to 3 000 nm

3.4
intense light source
ILS
device incorporating one or more non-laser sources of optical radiation of the wavelength range 250 nm to 3 000 nm and intended for creating biological effects in humans and animals

Note 1 to entry: It can operate in a continuous or pulsed regime.

3.5
retinal thermal hazard
potential for a thermal retinal injury resulting from optical radiation exposure in the wavelength range 380 nm to 1 400 nm

3.6
ultraviolet hazard
potential for skin and ocular acute and chronic adverse effects resulting from optical radiation exposure in the wavelength range 250 nm to 400 nm

4 Transmittance

4.1 General

The spectral transmittance of the ILS eye protector at the wavelengths between 250 nm and 3 000 nm shall be specified.

The spectral transmittance $\tau(\lambda)$ of the eye protector material shall be determined for normal incidence. The wavelength shall be determined at not more than 10 nm intervals with the central wavelength known to within ± 2 nm from 250 to 800 nm and within ± 4 nm above 800 nm. The bandwidth of the detector (full width half maximum) shall not exceed 5 nm.

Filters with angular dependent transmittance shall be measured at angles of incidence between at least 0° and 30°.

In addition, ILS eyewear may be designated F- or B- scale numbers according to 4.2 and/or 4.3.

4.2 F-classification

ILS eyewear may be designated F-scale number using the F-classification scheme described in Table 1.

NOTE The F-numbers in Table 1 are related to the shade numbers with some relaxation in the infrared region.

Luminous transmittance shall be determined according to 4.4.

Table 1 — Transmittance requirements for general purpose ILS filters

Scale number	Maximum spectral transmittance in the ultraviolet spectral range $\tau(\lambda)$			Luminous transmittance τ_v		Maximum mean transmittance in the infrared spectral range τ_{NIR}
	250 nm to 315 nm %	>315 nm to 380 nm %	>380 nm to 450 nm	Maximum %	Minimum %	780 nm to 3 000 nm %
F-1	0,1	0,4	τ_v	100	43,2	50
F-2	0,1	0,4	τ_v	43,2	17,8	50
F-3	0,1	0,4	τ_v	17,8	8,5	50
F-4	0,1	0,4	τ_v	8,5	3,2	50
F-5	0,1	0,4	τ_v	3,2	1,2	50
F-6	0,1	0,4	τ_v	1,2	0,44	50

4.3 B-classification

In many types of ILS it is the blue component of light that poses the greatest risk. To take account of this, a 'blue light' B-classification scheme described in Table 2 may be used.

Blue light transmittance τ_B should be determined as:

$$\tau_B = \frac{\int_{\lambda=380}^{\lambda=550} E(\lambda)B(\lambda)\tau(\lambda)d\lambda}{\int_{\lambda=380}^{\lambda=550} E(\lambda)B(\lambda)d\lambda} \times 100\,\%$$

where

$E(\lambda)$ is the spectral irradiance of the CIE Standard Illuminant D65, in W m^{-2} nm^{-1};

$B(\lambda)$ is blue light hazard weighting function (see Annex D);

$\tau(\lambda)$ is the spectral transmittance of filter material at wavelength λ;

$\Delta\lambda$ is the wavelength interval of the measurements, in nm.

Table 2 — Transmittance requirements for blue light ILS filters

Scale number	Maximum spectral transmittance in the ultraviolet spectral range $\tau_{UV}(\lambda)$			Blue light transmittance τ_B		Maximum mean transmittance in the infrared spectral range $\tau_{NIR}(\lambda)$
	250 nm to 315 nm %	>315 nm to 380 nm %	>380 nm to 450 nm	Maximum %	Minimum %	780 nm to 3 000 nm %
B-1	0,1	0,4	τ_B	100	43,2	50
B-2	0,1	0,4	τ_B	43,2	17,8	50
B-3	0,1	0,4	τ_B	17,8	8,5	50
B-4	0,1	0,4	τ_B	8,5	3,2	50
B-5	0,1	0,4	τ_B	3,2	1,2	50
B-6	0,1	0,4	τ_B	1,2	0,44	50

4.4 Luminous transmittance

The luminous transmittance τ_V of the protective filters intended for use by the ILS operator shall be determined as:

$$\tau_V = \frac{\int_{\lambda=380}^{\lambda=780} E(\lambda)V(\lambda)\tau(\lambda)d\lambda}{\int_{\lambda=380}^{\lambda=780} E(\lambda)V(\lambda)d\lambda}$$

where

$E(\lambda)$ is the spectral irradiance of the CIE Standard Illuminant D65, in W m^{-2} nm^{-1};

$V(\lambda)$ is spectral luminous efficiency;

$\Delta\lambda$ is the wavelength interval of the measurements, in nm;

$\tau(\lambda)$ is the spectral transmittance of filter material at wavelength λ.

NOTE There are no requirements for the luminous transmittance of the filters of eye protectors intended for use by ILS equipment patients/clients; these filters may be opaque.

5 Colour recognition

5.1 General

There are no requirements for colour neutrality.

If colour neutrality is claimed, spectral transmittance between 450 nm and 650 nm shall be uniform within ± 20 % of the mean transmittance value in this range.

5.2 Colour of the protective filters

The Commission Internationale de L'Eclairage (CIE) colour coordinates (x, y) of the protective filters intended for use by the ILS operator shall be determined as:

$$x = \frac{X}{X+Y+Z}$$

and

$$y = \frac{Y}{X+Y+Z}$$

where

$$X = \int_{\lambda=380}^{\lambda=780} \tau(\lambda)E(\lambda)\bar{x}(\lambda)d\lambda$$

$$Y = \int_{\lambda=380}^{\lambda=780} \tau(\lambda)E(\lambda)\bar{y}(\lambda)d\lambda$$

$$Z = \int_{\lambda=380}^{\lambda=780} \tau(\lambda)E(\lambda)\bar{z}(\lambda)d\lambda$$

and

$\bar{x}, \bar{y}$ and $\bar{z}$ are CIE colour matching functions;

$E(\lambda)$ is the spectral irradiance of the CIE Standard Illuminant D65, in W m^{-2} nm^{-1};

$\Delta\lambda$ is the wavelength interval of the measurements, in nm;

$\tau(\lambda)$ is the spectral transmittance of filter material at wavelength λ.

NOTE 1 The colour coordinates (x, y) of the protective filters might be optionally presented on a CIE chromaticity chart.

NOTE 2 There are no requirements for the colour perception of the filters of eye protectors intended for use by ILS equipment patients/clients; these filters may be opaque.

6 Auto darkening filters

Auto darkening filters shall provide the required levels of IR and UV protection specified in Tables 1 and 2 in light and dark states.

In the case of protective filters that exhibit a change of luminous transmittance in response to an exposure to incident optical radiation, the time taken by the eye protector to reach 3x the minimum luminous transmittance ("dark state") shall be determined.

Auto darkening filters powered by mains, batteries or photoelectric cells shall reduce the luminous transmittance (380 nm to 780 nm) to maximum of 30 % if the power supply is disconnected or malfunctions.

The minimum luminous transmittance in the light and dark states of auto darkening filters shall be specified, for the angles of incidence at least between 0° and 30°.

7 Construction of eye protectors

7.1 General

Mirror-finish or metalized finishes on filters or frames shall not be used.

NOTE Secondary reflections from frames or filters of protective eyewear, especially from concave surfaces, might increase the risk of uncontrolled exposure of the users.

7.2 Frames and side shields

Frames and side shields through which exposure to incident optical radiation could occur to the eyes shall give at least the same protection as the filters and shall be designed to prevent the leakage of optical radiation around the edges of protective eyewear.

7.3 Materials

When assessed in accordance with visual inspection, for those parts of the eye protector that come into contact with the skin, materials shall not be used which are known to be likely to cause skin irritation or any adverse effect on health.

Substances recommended for cleaning, maintenance or disinfection shall have no adverse effect on the eye protector and shall be known not to be likely to have any adverse effect upon the wearer, when applied in accordance with the eye protector manufacturer's instructions.

Information claiming that the product is innocuous shall be examined.

The following are examples of documents that shall be provided for examination:

— materials specifications;

— safety data sheets relating to the materials;

— information relating to the suitability of the materials for use with food, in medical devices, or other relevant applications;

— information relating to toxicological, allergenic, carcinogenic, toxic to reproduction, or mutagenic investigations on the materials.

If the eye or face protector incorporates metallic components which are in direct and prolonged contact with the user during wear, these components shall optionally be tested for nickel release according to ISO/TS 24348. The nickel release shall be less than 0,5 $\mu g/cm^2$/week.

NOTE National regulations may require assessment of nickel release to be mandatory.

When examined by a person with a visual acuity of at least 1,0 (6/6 or 20/20), when viewing without magnification but wearing the appropriate correction, if any, for near vision, there shall be no sharp edges, roughness or projection on any parts of the eye protector which are in contact, or potential contact, with the wearer, when the eye protector is worn, such as is likely to cause injury to the wearer.

7.4 Adjustment

Any part of the eye protector that can be adjusted, or removed by the wearer for the purpose of replacement (in accordance with the eye protector manufacturer's instructions), shall be so designed and manufactured as to facilitate adjustment, removal and attachment without the use of tools.

Any adjustment system incorporated within the eye protector shall be so designed and manufactured as not to become incorrectly adjusted without the wearer's knowledge under the foreseeable conditions of use.

Test by visual inspection, and adjustment/donning in accordance with the manufacturer's instructions, followed by a minimum of 5 min of wear while seated. During this wear period, the head shall be moved side to side and up/down 3 times per minute.

7.5 Removal of filters

The removal of individual filters from the frame shall only be possible with the use of tools.

If the filters consist of several individual filters (hybrid filters), they shall be assembled in such a way that they cannot be interchanged.

NOTE Hybrid filters should not delaminate after storage, when tested in accordance with Annex G and Annex H.

7.6 Material and surface quality

Except in a marginal area 5 mm wide, filters shall have no material or machining defects within an area of 30 mm diameter around the reference point that may impair vision, e.g. bubbles, scratches, inclusions, dull spots, pitting, mould marks, notches, reinforced areas, specks, beads, water specks, pocking, gas inclusions, splintering, cracks, polishing defects or undulations.

Test according to ISO 12311:2013, 6.2.

7.7 Field of view

Eye protectors intended for use by ILS equipment operators shall have a clear field of view at least ± 40° with respect to the corneal vertex in the vertical and horizontal directions for each eye.

NOTE There are no requirements for the field of view, material and surface defects of the filters of eye protectors intended for use by ILS equipment patients/clients; these filters may be opaque.

7.8 Optical properties

7.8.1 Variation in transmittance

The relative variations of the transmittance around the visual centre(s) shall not exceed ± 10 %.

The relative variations of the luminous transmittance around the visual centre(s) shall not exceed ± 10 %.

The relative variations of the luminous transmittance between left and right eye shall not exceed ± 10 %.

7.8.2 Spherical and astigmatic power

The oculars shall be tested at the reference points in the as worn position according to ISO 12311:2013, 8.1 after cleaning according to the manufacturer's instructions.

The spherical power and astigmatic power shall not exceed the following tolerances.

— Spherical power - Mean value of the optical power values in the two principal meridians [$(D_1 + D_2)/2$ dioptres]: ±0,06.

— Astigmatic power - Absolute difference between the optical power values in the two principal meridians ($|D_1 - D_2|$ dioptres): 0,06.

— Additional requirements for mounted oculars, one-piece and visor types: the maximum difference between the measured spherical powers of the right and left eye shall be 0,12 dioptres.

7.8.3 Local variations in refractive power

The image of the chart used to assess spherical and astigmatic power at of ISO 12311:2013, 8.3.1, shall be clear and sharp.

If during the measurements using the telescope a doubling or other aberration of the image is observed then the oculars shall be tested at the reference point in the as worn position according to ISO 12311:2013, 8.3.

7.8.4 Prismatic deviation of unmounted oculars

The oculars shall be tested at the reference point in the as worn position according to the test method in ISO 12311:2013, 8.1 after cleaning according to the manufacturer's instructions.

The prismatic power shall not exceed 0,12 prism dioptres.

7.8.5 Prismatic power difference for mounted oculars and one-piece protectors

The oculars shall be tested in the as worn position according to ISO 12311:2013, 8.2 after cleaning according to the manufacturer's instructions.

Use the diaphragm LB2 with Xb = (32,0±0,2) mm. Alternatively a diaphragm with a different Xb may be used if specified by the manufacturer.

The prismatic power difference shall not exceed the values in Table 3.

Table 3 — Maximum permitted prismatic power differences for mounted oculars and one piece protectors

Horizontal		Vertical
Base out prism dioptres	Base in prism dioptres	Prism dioptres
0,75	0,25	0,25

7.8.6 Narrow angle scattering (diffusion of light)

The value of the reduced luminance factor (diffusion) shall not exceed 1,0 $cd \cdot m^{-2} \cdot lx^{-1}$ when measured according to Annex E after cleaning according to the manufacturer's instructions.

7.9 Resistance to ignition

All parts of eye protectors that are exposed when worn shall be tested in accordance with Annex F and shall not ignite or continue to glow after removal of the heated rod.

7.10 Resistance to ageing by UV radiation

When tested in accordance with Annex G, the relative change of luminous transmittance shall not be greater than ± 10 % and the value of the reduced luminous factor shall not exceed 0,5 $cd \cdot m^{-2} \cdot lx^{-1}$.

7.11 Resistance to thermal ageing

When tested in accordance with Annex H, eye protectors shall not show apparent deformation.

8 Labelling

Each ILS eye protector shall be clearly and permanently marked to indicate the following:

a) model number;

b) manufacturer's identification;

c) eyewear classified according to 4.2 and/or 4.3 shall be marked F-# and/or B-#, respectively, where # = 1 to 6;

d) PD or PD range, if applicable.

If the information is marked on the filters, they shall not impair vision or the protective effect.

9 Information to be supplied by the manufacturer

Each ILS eye protector shall be supplied with printed user information in the language(s) of the country in which the eye protector is sold. This information shall include:

a) a clear statement of the model number of the eye protection;

b) a reproduction of the labelling in accordance with Clause 8 and an explanation of its meaning;

c) spectral transmittance in accordance with Clause 4, in graphical or tabular form at 10 nm intervals;

d) an explanation of the F-# and/or B-# marking conforming with 4.2 or 4.3 as appropriate, in tabular or graphic form at 10 nm intervals;

e) luminous transmittance in accordance with 4.4;

f) the CIE colour coordinates (x, y) of the protective filters in accordance with 5.2, with optional presentation on a CIE chromaticity chart;

g) PD or PD range, if applicable;

h) for auto darkening filters, the minimum luminous transmittance in the light and dark states;

i) for auto darkening filters powered by electrical mains, batteries or photovoltaic cells, specification of power settings and power tolerances;

j) instructions for use, care, storage, cleaning and disinfection of the eye protector;

k) instructions for inspection and guidance on when the eye protector should be replaced;

l) the name and address of the manufacturer or supplier of the eye protector.

Annex A
(informative)

Filter protection factor (FPF)

A.1 Neither optical density nor shade numbers are suitable for characterization of ILS protective filters as these characteristics do not take into account the difference in the effect of different wavelengths on the eye, whereas exposure limit values (ELVs) (taken from Reference[10]) refer to effective, e.g. spectrally weighted values.

A.2 FPF is defined as:

$$FPF_{BL} = \frac{\int_{\lambda=300}^{\lambda=700} E(\lambda)B(\lambda)d\lambda}{\int_{\lambda=300}^{\lambda=700} E(\lambda)B(\lambda)\tau(\lambda)d\lambda} \quad \text{(A.1)}$$

for blue light hazards;

$$FPF_{RTh} = \frac{\int_{\lambda=380}^{\lambda=1400} E(\lambda)R(\lambda)d\lambda}{\int_{\lambda=380}^{\lambda=1400} E(\lambda)R(\lambda)\tau(\lambda)d\lambda} \quad \text{(A.2)}$$

for retinal thermal hazards;

$$FPF_{UV} = \frac{\int_{\lambda=180}^{\lambda=400} E(\lambda)S(\lambda)d\lambda}{\int_{\lambda=180}^{\lambda=400} E(\lambda)S(\lambda)\tau(\lambda)d\lambda} \quad \text{(A.3)}$$

for actinic ultraviolet hazards; and

$$FPF_{IR,lens} = \frac{\int_{\lambda=780}^{\lambda=3000} E(\lambda)d\lambda}{\int_{\lambda=780}^{\lambda=3000} E(\lambda)\tau(\lambda)d\lambda} \quad \text{(A.4)}$$

for infrared lens hazards;

where

$E(\lambda)$	is the spectral irradiance of the ILS device, in W m^{-2} nm^{-1};
$B(\lambda)$, $R(\lambda)$ and $S(\lambda)$	are blue light, retinal thermal and actinic ultraviolet hazard weighting functions, respectively (see Annex D);
$\Delta\lambda$	is the wavelength interval of the measurements, in nm;
$\tau(\lambda)$	is the spectral transmittance of eye protector material at wavelength λ.

A.3 FPF quantifies the reduction of biologically effective ocular exposure and takes into account the effect of different wavelengths on the eye. To calculate FPF for a specific ILS device, the emission spectrum of the ILS equipment and protective filter spectral transmittance are needed.

A.4 FPF directly relates to the risk assessment. Key stages of such an assessment are to:

a) calculate the weighted radiance, weighted irradiance or weighted radiant exposure using spectral irradiance of ILS equipment provided by the ILS equipment manufacturer (or measure actual spectral irradiance, if data are not available);

NOTE Spectral irradiance might be different for the operator of ILS equipment and patient/client.

b) determine the ELVs for exposure duration and type of hazard;

c) compare measured values with the ELVs.

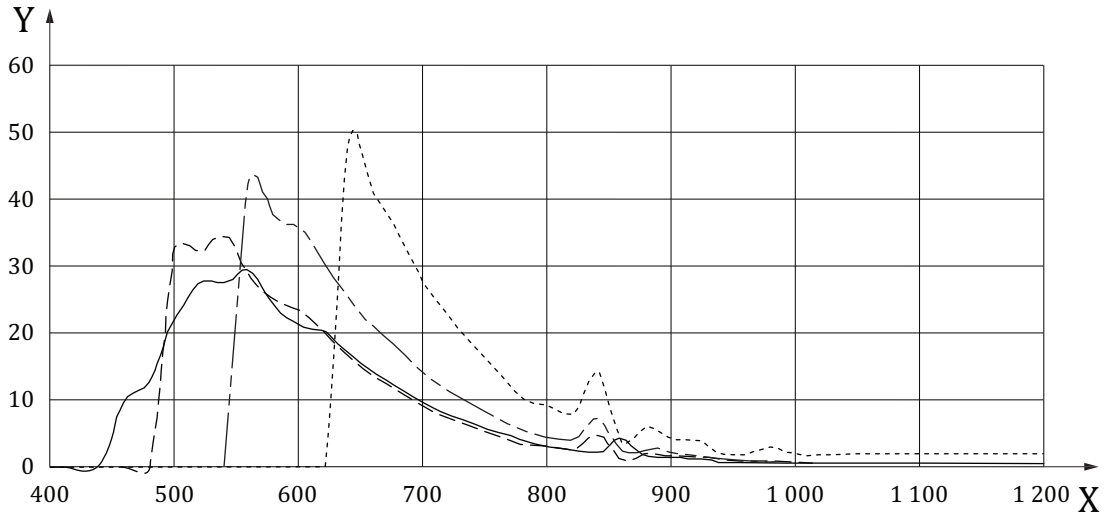
A.5 If the risk assessment demonstrates that retinal exposure limits are exceeded, protective eyewear should be worn. Minimal FPF of protective eyewear should be at least equal to or higher than the required level of exposure reduction. The required level of reduction of exposure is likely to be different for a patient/client and operator, therefore, FPF of protective eyewear for patient and operator might be different.

Annex B
(informative)

Calculation of FPF for protective eyewear — Example 1

B.1 The ILS manufacturer should specify the required F-# and/or B-#. The calculations shown here are intended to help when the required F-# and/or B-# have not been specified.

B.2 ILS device A for cosmetic applications is supplied with four different attachment tools, filtering spectral emission of the device at 440 nm, 500 nm, 560 nm and 640 nm, as illustrated in Figure B.1.

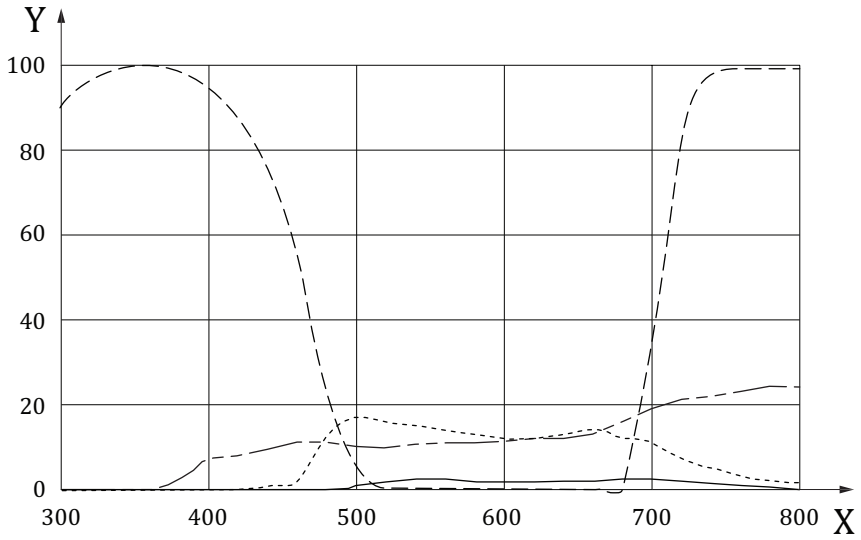


Key

X		wavelength, nm
Y		spectral irradiance, arbitrary units
	- – – – – –	500 nm filter
	— – – ——	560 nm filter
	----------	640 nm filter
	————	440 nm filter

Figure B.1 — Spectral irradiance of ILS device A with different filtering attachments

B.3 Spectral transmittance of eyewear protective filters 1, 2, 3 and 4 is shown in Figure B.2. Transmittance of the filters and spectral irradiance of the ILS device were measured at 2 nm spectral intervals.



Key

X		wavelength, nm
Y		transmittance %
- – – – – –		filter 1
— – – ——		filter 2
----------		filter 3
————————		filter 4

Figure B.2 — Transmittance of eyewear protective filters 1, 2, 3 and 4

B.4 FPF is calculated for blue light and retinal thermal hazards, using Formulae (A.1) and (A.2), correspondingly, where

$E(\lambda)$ data are taken from Figure B.1;

$B(\lambda)$ and $R(\lambda)$ are hazard weighting functions (see Annex D);

$\Delta\lambda$ is the wavelength interval of the measurements (2 nm in this example);

$\tau(\lambda)$ is the spectral transmittance of filters 1, 2, 3 and 4 taken from Figure B.2.

B.5 FPFs for ultraviolet and infrared lens hazards are not applicable for ILS device A because its spectral emission is very low in these hazard spectral regions and this source does not present a risk of UV or IR over-exposure.

B.6 Calculated FPF values of the eyewear protective filters for different filtering attachments of ILS device A are presented in Table B.1.

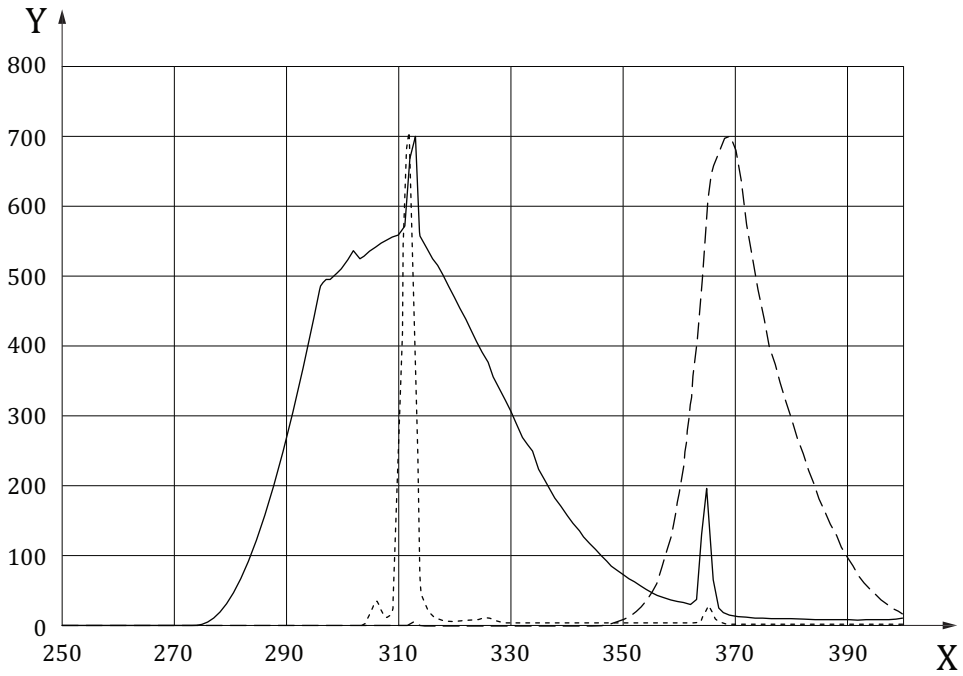
Table B.1 — FPF of filters 1, 2 3 and 4 and different filtering attachments of ILS device A

	440 nm	500 nm	560 nm	640 nm
FPF for blue light hazard				
Filter 1	15	6	7	8
Filter 2	10	10	9	7
Filter 3	2	37	90	15
Filter 4	300	46	49	44
FPF for retinal thermal hazard				
Filter 1	11	7	8	10
Filter 2	9	8	7	6
Filter 3	3	10	7	3
Filter 4	95	48	52	55

Annex C
(informative)

Calculation of FPF for protective eyewear — Example 2

C.1 ILS device B for medical applications is supplied with three interchangeable lamps: lamp 1, lamp 2 and lamp 3. Spectral irradiance of the lamps of ILS device B is shown in Figure C.1.

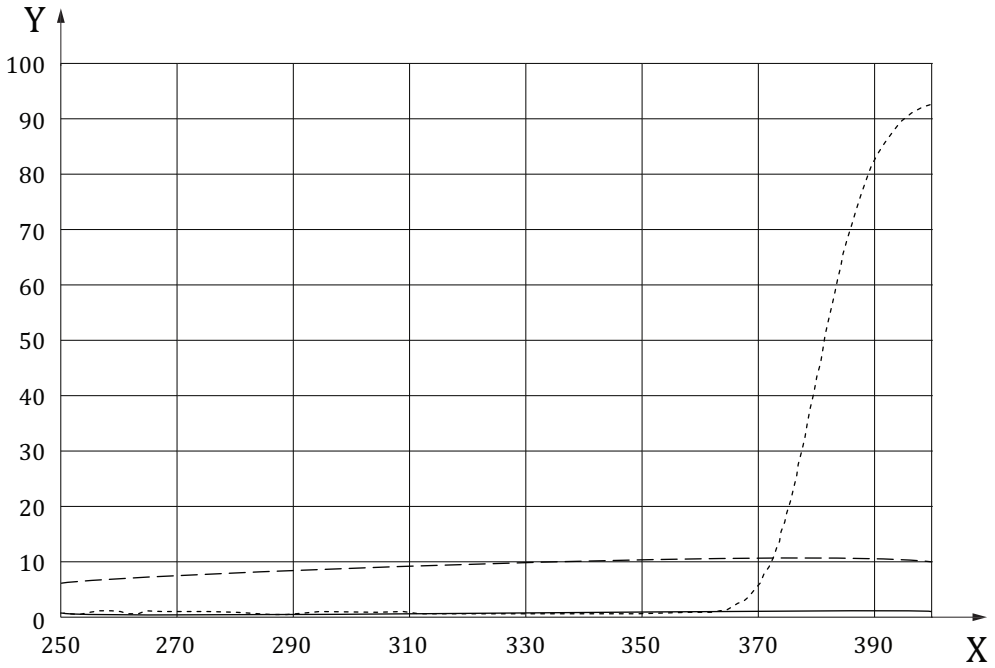


Key

X	wavelength, nm
Y	spectral irradiance, arbitrary units
————	lamp 1
- – – – – –	lamp 2
----------	lamp 3

Figure C.1 — Spectral irradiance of ILS device B with interchangeable lamps 1, 2 and 3

C.2 Spectral transmittance of eyewear protective filters 5, 6 and 7 is shown in Figure C.2. Transmittance of the filters and spectral irradiance of the ILS device were measured at 2 nm spectral intervals.



Key

X	wavelength, nm
Y	transmittance %
———	filter 5
– – – – –	filter 6
----------	filter 7

Figure C.2 — Spectral transmittance of eyewear protective filters 5, 6 and 7

C.3 FPF is calculated for blue light and ultraviolet hazards, using Formulae (A.1) and (A.3), correspondingly, where

$E(\lambda)$ data are taken from Figure C.1;

$B(\lambda)$ and $S(\lambda)$ are hazard weighting functions (see Annex D);

$\Delta\lambda$ is the wavelength interval of the measurements (2 nm in this example);

$\tau(\lambda)$ is spectral transmittance of filters 5, 6 and 7 taken from Figure C.2.

C.4 FPFs for retinal thermal and infrared lens hazards are not applicable for ILS device B because its spectral emission is very low in these hazard spectral regions and this source does not present a risk of UV or IR over-exposure.

C.5 Calculated FPF values of the eyewear protective filters for interchangeable lamps 1, 2 and 3 of ILS device B are presented in Table C.1.

Table C.1 — FPF of filters 5, 6 and 7 and interchangeable lamps 1, 2 and 3 of ILS device B

	Lamp 1	Lamp 2	Lamp 3
FPF for ultraviolet hazard			
Filter 5	140	95	122
Filter 6	12	10	10
Filter 7	175	8	194
FPF for blue light hazard			
Filter 5	110	93	115
Filter 6	10	10	10
Filter 7	36	3	30

Annex D
(informative)

Spectral hazard weighting functions

For guidance, spectral hazard weighting functions $S(\lambda)$, $B(\lambda)$ and $R(\lambda)$, cited in Reference,[10] are given in Table D.1 and Table D.2.

Table D.1 — Ultraviolet hazard weighting function $S(\lambda)$

λ nm	S(λ)	λ nm	S(λ)	λ nm	S(λ)	λ nm	S(λ)	λ nm	S(λ)
180	0,012 0	228	0,173 7	276	0,943 4	324	0,000 520	372	0,000 086
181	0,012 6	229	0,181 9	277	0,927 2	325	0,000 500	373	0,000 083
182	0,013 2	230	0,190 0	278	0,911 2	326	0,000 479	374	0,000 080
183	0,013 8	231	0,199 5	279	0,895 4	327	0,000 459	375	0,000 077
184	0,014 4	232	0,208 9	280	0,880 0	328	0,000 440	376	0,000 074
185	0,015 1	233	0,218 8	281	0,856 8	329	0,000 425	377	0,000 072
186	0,015 8	234	0,229 2	282	0,834 2	330	0,000 410	378	0,000 069
187	0,016 6	235	0,240 0	283	0,812 2	331	0,000 396	379	0,000 066
188	0,017 3	236	0,251 0	284	0,790 8	332	0,000 383	380	0,000 064
189	0,018 1	237	0,262 4	285	0,770 0	333	0,000 370	381	0,000 062
190	0,019 0	238	0,274 4	286	0,742 0	334	0,000 355	382	0,000 059
191	0,019 9	239	0,286 9	287	0,715 1	335	0,000 340	383	0,000 057
192	0,020 8	240	0,300 0	288	0,689 1	336	0,000 327	384	0,000 055
193	0,021 8	241	0,311 1	289	0,664 1	337	0,000 315	385	0,000 053
194	0,022 8	242	0,322 7	290	0,640 0	338	0,000 303	386	0,000 051
195	0,023 9	243	0,334 7	291	0,618 6	339	0,000 291	387	0,000 049
196	0,025 0	244	0,347 1	292	0,598 0	340	0,000 280	388	0,000 047
197	0,026 2	245	0,360 0	293	0,578 0	341	0,000 271	389	0,000 046
198	0,027 4	246	0,373 0	294	0,558 7	342	0,000 263	390	0,000 044
199	0,028 7	247	0,386 5	295	0,540 0	343	0,000 255	391	0,000 042
200	0,030 0	248	0,400 5	296	0,498 4	344	0,000 248	392	0,000 041
201	0,033 4	249	0,415 0	297	0,460 0	345	0,000 240	393	0,000 039
202	0,037 1	250	0,430 0	298	0,398 9	346	0,000 231	394	0,000 037
203	0,041 2	251	0,446 5	299	0,345 9	347	0,000 223	395	0,000 036
204	0,045 9	252	0,463 7	300	0,300 0	348	0,000 215	396	0,000 035
205	0,051 0	253	0,481 5	301	0,221 0	349	0,000 207	397	0,000 033
206	0,055 1	254	0,500 0	302	0,162 9	350	0,000 200	398	0,000 032
207	0,059 5	255	0,520 0	303	0,120 0	351	0,000 191	399	0,000 031
208	0,064 3	256	0,543 7	304	0,084 9	352	0,000 183	400	0,000 030
209	0,069 4	257	0,568 5	305	0,060 0	353	0,000 175		
210	0,075 0	258	0,594 5	306	0,045 4	354	0,000 167		

Table D.1 *(continued)*

λ nm	**S(λ)**	λ nm	**S(λ)**	λ nm	**S(λ)**	λ nm	**S(λ)**	λ nm	**S(λ)**
211	0,078 6	259	0,621 6	307	0,034 4	355	0,000 160		
212	0,082 4	260	0,650 0	308	0,026 0	356	0,000 153		
213	0,086 4	261	0,679 2	309	0,019 7	357	0,000 147		
214	0,090 6	262	0,709 8	310	0,015 0	358	0,000 141		
215	0,095 0	263	0,741 7	311	0,011 1	359	0,000 136		
216	0,099 5	264	0,775 1	312	0,008 1	360	0,000 130		
217	0,104 3	265	0,810 0	313	0,006 0	361	0,000 126		
218	0,109 3	266	0,844 9	314	0,004 2	362	0,000 122		
219	0,114 5	267	0,881 2	315	0,003 0	363	0,000 118		
220	0,120 0	268	0,919 2	316	0,002 4	364	0,000 114		
221	0,125 7	269	0,958 7	317	0,002 0	365	0,000 110		
222	0,131 6	270	1,000 0	318	0,001 6	366	0,000 106		
223	0,137 8	271	0,991 9	319	0,001 2	367	0,000 103		
224	0,144 4	272	0,983 8	320	0,001 0	368	0,000 099		
225	0,150 0	273	0,975 8	321	0,000 819	369	0,000 096		
226	0,158 3	274	0,967 9	322	0,000 670	370	0,000 093		
227	0,165 8	275	0,960 0	323	0,000 540	371	0,000 090		

Table D.2 — Blue light hazard *B*(λ) and retinal thermal hazard *R*(λ) weighting functions

λ nm	***B*(λ)**	***R*(λ)**
300 – <380	0,01	—
380	0,01	0,1
385	0,013	0,13
390	0,025	0,25
395	0,05	0,5
400	0,1	1
405	0,2	2
410	0,4	4
415	0,8	8
420	0,9	9
425	0,95	9,5
430	0,98	9,8
435	1	10
440	1	10
445	0,97	9,7
450	0,94	9,4
455	0,9	9
460	0,8	8
465	0,7	7
470	0,62	6,2

Table D.2 *(continued)*

λ nm	$B(\lambda)$	$R(\lambda)$
475	0,55	5,5
480	0,45	4,5
485	0,32	3,2
490	0,22	2,2
495	0,16	1,6
500	0,1	1
> 500 – ≤ 600	$10^{0,02\cdot(450-\lambda)}$	1
> 600 – ≤ 700	0,001	1
> 700 – ≤ 1 050	—	$10^{0,002\cdot(700-\lambda)}$
> 1 050 –≤ 1 150	—	0,2
> 1 150 –≤ 1 200	—	$0,2\cdot10^{0,02\cdot(1\,150-\lambda)}$
> 1 200 – 1 400	—	0,02

Annex E
(normative)

Test method for narrow angle scattering (diffusion of light)

E.1 Principle

The luminance (*Ls*) of an illuminated ocular is a measure of its light diffusion and is proportional to the illuminance (*E*). The proportionality factor is the luminance factor $l = Ls/E$, which is expressed in candelas per square metre per lux:

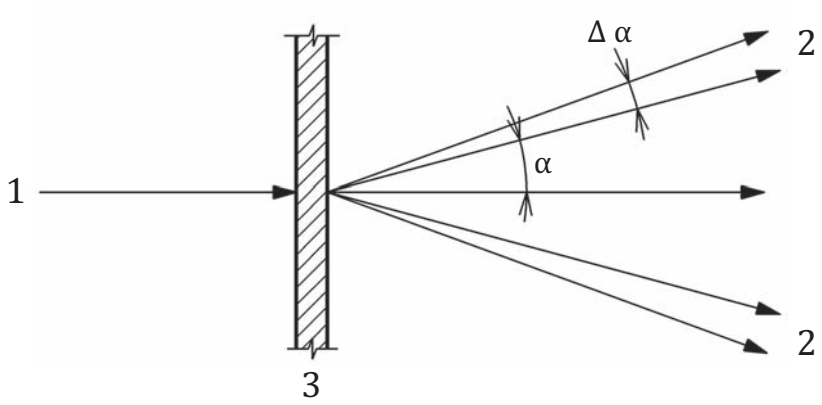
$$\frac{(cd/m^2)}{lx}$$

To obtain a factor l^* which is independent of the transmittance of the ocular, the luminance factor is divided by the transmittance.

$$l^* = Ls/\tau E$$

This quantity is known as the reduced luminance factor and is expressed in the same units as the luminance factor.

NOTE Most oculars have diffusion properties which are symmetrical about the optical axis. For these oculars, the mean value of the reduced luminance factor is measured within an angle limited by the two cones shown in Figure E.1. This mean value depends upon values α and Δα.



Key

1 incident light on optical axis
2 diffused light
3 ocular

Figure E.1 — Diffusion angles

E.2 Test methods

E.2.1 General

Two test methods are specified which use the same measurement principle. The “basic method” detailed in E.2.2 may be used for oculars without corrective effect and for all shade numbers. The “simplified method” detailed in E.2.3 has to be used for oculars with corrective effect.

The results obtained with the two methods may be considered to be equivalent; whichever method is used the relative measurement uncertainty for the reduced luminance factor shall not be greater than 25 %.

Measurements of light diffusion shall be taken at the visual centre of the ocular. If the visual centre is not known then the boxed centre shall be used.

NOTE Visual centre and boxed centre are as defined in ISO 4007.

E.2.2 Basic method

E.2.2.1 Apparatus

The arrangement is shown in Figure E.2.

The spherical concave mirror H_1 forms an image of light L of identical dimensions at diaphragm LB. The spherical concave mirror H_3 forms an image of diaphragm LB in the plane of diaphragms B_L and B_R. The achromatic lens A is positioned immediately behind the diaphragm so that a reduced image of the test sample in position P appears on diffusing screen MS. The image of iris diaphragm IB_1 is formed at the same time as IB_2.

The arrangement collects all the light originating from the filter between angles $\alpha = 1{,}5°$ and $\alpha + \Delta\alpha = 2°$ in relation to the optical axis.

E.2.2.2 Procedure

The ocular is placed in the parallel beam at position P, then diaphragm B_L is put in place. The flux Φ_{1L} falling onto the photodetector corresponds to the undiffused light transmitted by the sample. Diaphragm B_L is then replaced by annular diaphragm B_R; flux Φ_{1R} falling onto the photodetector corresponds to the total diffused light originating from the filter and from the apparatus. The test sample is then placed at position P’. The flux Φ_{2R} which then falls onto the photodetector corresponds to the diffused light coming from the apparatus only.

The difference Φ_{1R} - Φ_{2R} corresponds to the light diffused by the filter. The mean reduced luminance factor l^* for the solid angle ω is calculated from the preceding fluxes by means of the formula:

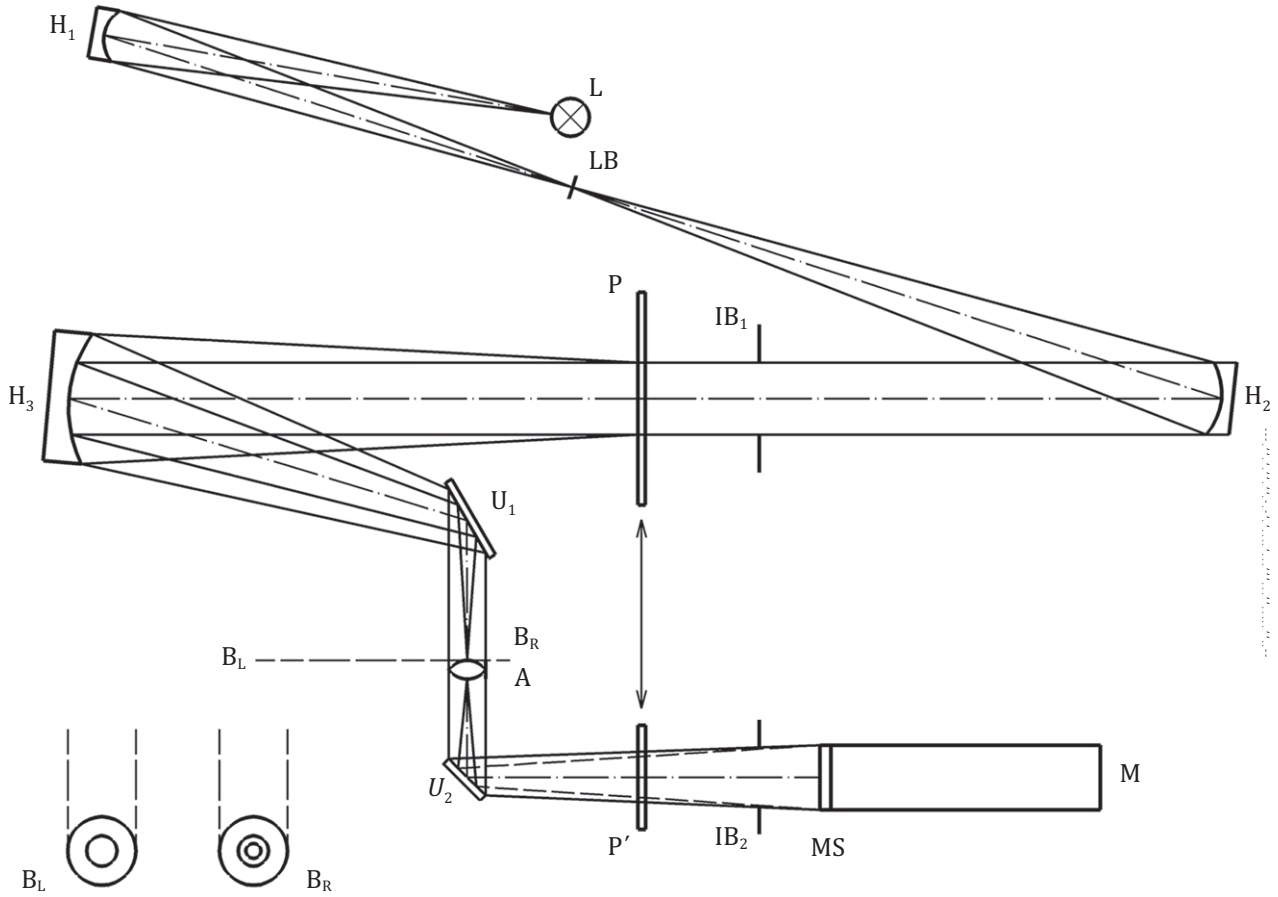
$$l^* = \frac{l}{\omega} \cdot \frac{\Phi_{1R} - \Phi_{2R}}{\Phi_{1L}}$$

where

Φ_{1R}, Φ_{2R} are the luminance fluxes with the annular diaphragm;

Φ_{1L} is the luminous flux with the circular diaphragm;

ω is the solid angle defined by the annular diaphragm.



Key

L	high-pressure xenon lamp (for example XB0 150 W or CSX150 W)
H_1	spherical concave mirror; nominal focal length 150 mm; nominal diameter 40 mm
H_2	spherical concave mirror; nominal focal length 300 mm; nominal diameter 40 mm
H_3	spherical concave mirror; nominal focal length 300 mm; nominal diameter 70 mm
A	achromatic lens; nominal focal length 200 mm; nominal diameter 30 mm
U_1, U_2	flat mirrors
B_R	annular diaphragm; diameter of outer circle (21,0 ± 0,1) mm, diameter of inner circle (15,75 ± 0,10) mm (see note below)
B_L	circular diaphragm; diameter of aperture (7,5 ± 0,1) mm
M	photomultiplier corrected according to curve V (λ) with diffusing screen [V (λ) is spectral luminous efficiency for photopic vision defined in ISO 4007]
IB_1	iris-diaphragm to adjust diameter of field of measurement
IB_2	iris-diaphragm to eliminate edge effects from IB1
LB	circular diaphragm, diameter of aperture (1,0 ± 0,1) mm
MS	diffusing screen
P, P’	positions of test ocular

Figure E.2 — Arrangement of apparatus for measurement of light diffusion

The diameters of the annular diaphragm circles shall be measured to an uncertainty not exceeding 0,01 mm in order that the solid angle ω may be determined accurately; any deviation from the nominal diameters shall be taken into account by calculation.

E.2.3 Simplified method

E.2.3.1 Apparatus

The test arrangement is shown in Figure E.3.

NOTE 1 The measurement principle is identical to that given in E.2.2, but the diameter of the measuring zone is smaller (approximately 2,5 mm) and the test arrangement is simplified.

The beam of the laser (L) is expanded using the two lenses L_1 and L_2 and is directed towards the measuring point of the ocular (P). Ocular (P) is positioned in such a way that it can rotate around the axis of the beam.

The deviation of the beam is a function of the prismatic refractive power at the measuring point.

The annular or circular diaphragm, whichever is chosen, is at a distance of (400 ± 2) mm from the centre of the ocular.

The lens A then produces the image of the centre of the ocular on the photoreceptor S.

The part of the test arrangement, comprising the diaphragms, the lens and the receptor, is designed to rotate about the vertical axis through the centre of the ocular.

The ocular and the detector part of the apparatus have to pivot in order to compensate for any prismatic refractive power of the ocular.

NOTE 2 For oculars without corrective effect, it is not necessary, in most cases, for the ocular and the detector part to pivot.

E.2.3.2 Procedure

E.2.3.2.1 Calibration of the apparatus

Set up the apparatus, the essential features of which are shown in Figure E.3, without the ocular in place. Put the annular diaphragm B_R in place. Rotate the detector part of the apparatus (consisting of a photoreceptor S, a lens A and the annular diaphragm B_R) horizontally about P so as to align the light beam from the beam expander (consisting of a lens L_1 with a typical focal length of 10 mm, a lens L_2 with a typical focal length of 30 mm and a circular diaphragm B with a pinhole of sufficient size so as to provide a uniform beam) with the centre of the annular diaphragm B_R. Measure the flux Φ_{1R} falling onto the photoreceptor S, corresponding to the total diffused light.

Replace the annular diaphragm B_R by the circular diaphragm B_L.

Measure the flux Φ_{1L} falling onto the photoreceptor, corresponding to the total non-diffused light. Obtain the reduced luminance factor for the apparatus, l^*_a, for the solid angle ω using the following equation:

$$l_a^* = \frac{l}{\omega} \cdot \frac{\Phi_{1R}}{\Phi_{1L}}$$

where

Φ_{1R} is the luminous flux without the ocular in the parallel beam and with the annular diaphragm B_R in place;

Φ_{1L} is the luminous flux without the ocular in the parallel beam and with circular diaphragm B_L in place;

ω is the solid angle defined by the annular diaphragm BR.

E.2.3.2.2 Testing of the ocular

Place the ocular in the parallel beam at position P as shown in Figure E.3. Repeat E.2.3.2.1 with the ocular in place, and with the ocular rotated about the axis of the beam to a position such that the prismatic deviation by the ocular is horizontal.

Rotate the detector part of the apparatus so that the light beam falls on the centre of B_R. Obtain the reduced luminance factor for the apparatus including the ocular, l^*_g, for the solid angle ω using the following equation:

$$l^*_g = \frac{l}{\omega} \cdot \frac{\Phi_{2R}}{\Phi_{2L}}$$

where

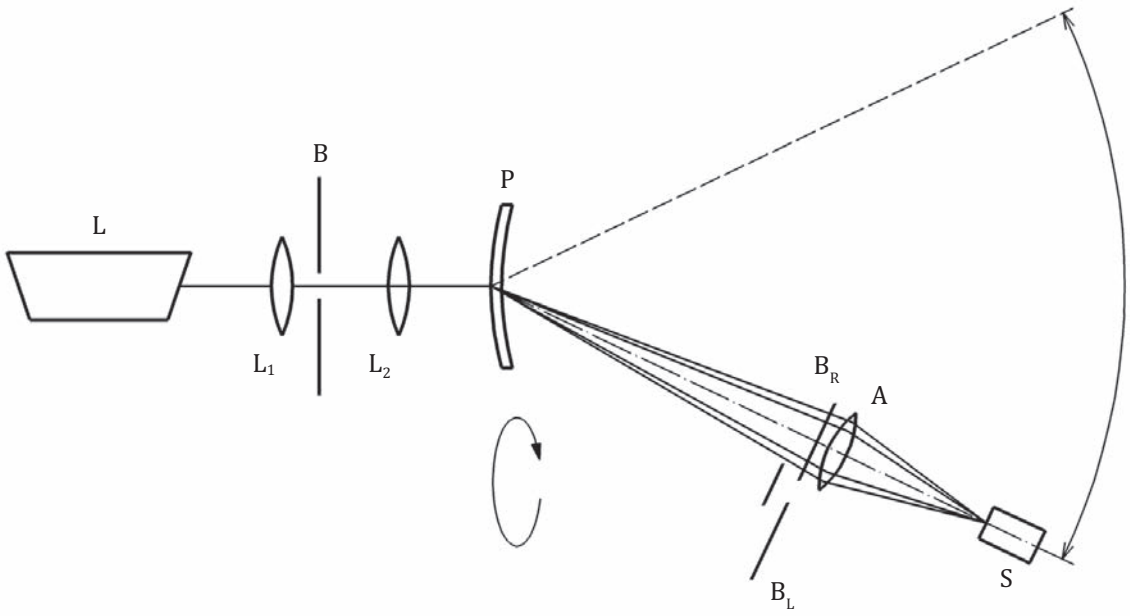
Φ_{2R} is the luminous flux with the ocular in the parallel beam and with the annual diaphragm B_R in place;

Φ_{2L} is the luminous flux with the ocular in the parallel beam and with the circular diaphragm B_L in place;

ω is the solid angle defined by the annular diaphragm B_R.

Then calculate the reduced luminance factor l^* of the ocular using the following equation:

$$l^* = l^*_g - l^*_a$$



Key

L laser with wavelength of (600 ± 70) nm (class 2 laser recommended, < 1 mW, diameter of beam between 0,6 mm and 1,0 mm)

L_1 10 mm nominal focal length lens

L_2 30 mm nominal focal length lens

B circular diaphragm (a hole of 0,1 mm approximately produces a uniform light beam)

P ocular sample

B_R annular diaphragm, the diameter of the external circle being (28,0 ± 0,1) mm and the inner circle (21,0 ± 0,1) mm (see NOTE)

B_L circular diaphragm of 10 mm nominal diameter

A lens, 200 mm nominal focal length and 30 mm nominal diameter

S photoreceptor

NOTE The focal length of the lenses is only given as a guide. Other focal lengths may be used, for example, if a wider beam is desired or a smaller image of the sample is to be formed on the receptor.

Figure E.3 — Arrangement of apparatus for measurement of light diffusion — Simplified method

The diameters of the annular diaphragm circles shown in Figure E.3 shall be measured to an uncertainty not exceeding 0,01 mm in order that the solid angle ω may be determined accurately; any deviation from the nominal diameters shall be taken into account by calculation.The distance between the annular/circular diaphragm and the centre of the ocular shall be (400 ± 2) mm.

Annex F
(normative)

Test for resistance to ignition

F.1 Apparatus

F.1.1 **Steel rod**, (300 ± 3) mm long and 6 mm nominal diameter with end faces which are flat and perpendicular to its longitudinal axis.

F.1.2 **Heat source**.

F.1.3 **Thermocouple** and **temperature indicating device**.

F.1.4 **Timer**, capable of measuring an elapsed time of 10 s with an uncertainty of ± 0,1 s.

F.2 Procedure

Heat one end of the steel rod over a length of at least 50 mm to a temperature of (650 ± 20) °C. Measure the temperature of the rod by means of the thermocouple attached at a distance of (20 ± 1) mm from the heated end of the rod. Press the heated face of the rod (long axis vertically) against the surface of the test sample (the contact force being equal to the weight of the rod) for a period of (5,0 ± 0,5) s, and then remove it.

Carry out the test on all externally exposed parts of the eye-protector, except elastic headbands and textile edging. Carry out a visual inspection during the test in order to establish whether the test samples ignite or continue to glow.

Perform the test in an environment of temperature (23 ± 5) °C.

Annex G
(normative)

Test for resistance to ultraviolet radiation

G.1 Apparatus

G.1.1 Fused silica envelope high-pressure zenon lamp. The power of the lamp shall be between 400 W and 500 W, with a preferred value of 450 W. The spectral transmittance of the lamp envelope shall be at least 30 % at 200 nm.

G.2 Procedure

New specimens are used for this test. The test equipment is operated within an environment of temperature (23 ± 5) °C.

Expose the external face of the ocular to radiation from a fused silica envelope high-pressure xenon lamp (G.1.1).

The angle of incidence of the radiation of the specimen surface shall be essentially perpendicular. The distance from the axis of the lamp to the nearest point on the sample shall be (300 ± 10) mm. The exposure time shall be (50 ± 0.2) h at a lamp power of 450 W.

New lamps shall be burned in for (50 ± 0,2) h.

Annex H
(normative)

Test for stability at elevated temperature

New specimens are used for this test.

H.1 Apparatus

H.1.1 Oven, capable of maintaining a temperature of (55 ± 2) °C.

H.2 Procedure

Place the specimen in a position corresponding to normal use, in the oven for (60 ± 5) min at a temperature of (55 ± 5) °C. Then remove it and allow to stabilize at (23 ± 5) °C for a minimum of 60 min prior to visual examination.

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ICS 13.340.20

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