INTERNATIONAL STANDARD

ISO 8980-3

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Ophthalmic optics — Uncut finished spectacle lenses —

Part 3:
Transmittance specifications and test methods

Optique ophtalmique — Verres de lunettes finis non détourés —

Partie 3: Spécifications relatives au facteur de transmission et méthodes d'essai

Reference number
ISO 8980-3:2003(E)

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Contents

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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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

ISO 8980-3 was prepared by Technical Committee ISO/TC 172, *Optics and optical instruments*, Subcommittee SC 7, *Ophthalmic optics and instruments*.

This second edition cancels and replaces the first edition (ISO 8980-3:1999), subclause 6.5 of which has been technically revised.

ISO 8980 consists of the following parts, under the general title *Ophthalmic optics — Uncut finished spectacle lenses*:

- *Part 1: Specifications for single-vision and multifocal lenses*
- *Part 2: Specifications for progressive power lenses*
- *Part 3: Transmittance specifications and test methods*
- *Part 4: Specifications and test methods for anti-reflective coatings*

Ophthalmic optics — Uncut finished spectacle lenses —

Part 3:
Transmittance specifications and test methods

1 Scope

This part of ISO 8980 specifies requirements for the transmittance properties of uncut finished spectacle lenses.

This part of ISO 8980 is not applicable to

- spectacle lenses having particular transmittance or absorption characteristics prescribed for medical reasons;
- products where specific personal protective equipment transmittance standards apply.

NOTE Optical and geometric requirements for uncut finished spectacle lenses are specified in ISO 8980-1 and ISO 8980-2.

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.

ISO 13666, *Ophthalmic optics — Spectacle lenses — Vocabulary*

ISO 14889, *Ophthalmic optics — Spectacle lenses — Fundamental requirements for uncut finished lenses*

ISO/CIE(1) 10526, *CIE standard illuminants for colorimetry*

ISO/CIE 10527, *CIE standard colorimetric observers*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 13666 apply.

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1) International Commission on Illumination, Kegelgasse 27, A-1030 Vienna.

4 Classification

Spectacle lenses are classified with respect to transmittance as follows:

a) clear spectacle lenses;

b) uniformly tinted spectacle lenses;

c) gradient-tinted spectacle lenses;

d) photochromic spectacle lenses;

e) polarizing spectacle lenses.

NOTE Two or more of the above classifications may be combined.

5 Requirements

5.1 General

The requirements shall apply at a temperature of 23°C ± 5°C, and shall apply to the design reference point, unless specified otherwise. Measurements shall be made with a test beam having a minimum width of 5 mm in any direction.

5.2 General transmittance requirements

The general transmittance requirements specified in ISO 14889 shall apply.

Spectacle lenses shall be attributed to five luminous transmittance categories as specified in Table 1, and shall be tested as described in Clause 6.

NOTE Table 1 also includes the UV requirements for spectacle lenses, but those spectacle lenses of category 0 for which no specific claim is made as to UV transmittance performance are excluded from the UV requirements of Table 1.

For categories 0, 1, 2 and 3 the luminous transmittance τ_v of the spectacle lens at the design reference point shall not lie outside the limits of the stated category by more than 2 % absolute.

For category 4, the luminous transmittance τ_v of the spectacle lens at the design reference point shall not lie outside the limits of that category by more than 20 % relative to the stated luminous transmittance.

5.3 Requirements for driving

Spectacle lenses to be used by vehicle drivers shall conform to the specific requirements for transmittance specified in ISO 14889.

5.4 Transmittance requirements for special types of spectacle lenses

5.4.1 Photochromic spectacle lenses

5.4.1.1 General

When tested by the methods described in 6.5, the luminous transmittance values of a photochromic spectacle lens in its faded and in its darkened state shall be used to identify the appropriate categories in accordance with Table 1.

Table 1 — Categories for luminous transmittance and the related permissible transmittance in the ultraviolet solar spectral range

Categories	Visible spectral range		Ultraviolet spectral range	
	Range of luminous transmittance τ_V		Maximum value of solar UV-A transmittance τ_{SUVA}	Maximum value of solar UV-B transmittance τ_{SUVB}
	from over %	to %	over 315 nm to 380 nm UV-A	over 280 nm to 315 nm UV-B
0	80,0	100	τ_V	τ_V
1	43,0	80,0		0,125 τ_V
2	18,0	43,0		
3	8,0	18,0	0,5 τ_V	
4	3,0	8,0		1,0 % absolute

NOTE 1 Photochromic spectacle lenses are usually attributed to two categories, corresponding to the faded state and to the darkened state.

NOTE 2 The UV requirements of photochromic spectacle lenses in the darkened state may be checked in the faded state, if the UV requirements for the darkened state are met in the faded state.

NOTE 3 It is recommended that uniform or gradient tints should be ordered by reference to a manufacturer's identification code, name or reference number.

5.4.1.2 Photochromic response

When tested by the methods described in 6.5.3.1 to 6.5.3.3, the ratio of the luminous transmittance of a photochromic specimen (see 6.5.1) in its faded state $\tau_V(0)$ and, after 15 min irradiation, in its darkened state $\tau_V(15)$ shall be at least 1,25, i.e.

$$\frac{\tau_{V(0)}}{\tau_{V(15)}} \geqslant 1{,}25 \qquad (1)$$

5.4.1.3 Photochromic response at various temperatures (optional)

If photochromic temperature sensitivity is stated, it shall be determined by measuring the luminous transmittance of the specimen (see 6.5.1) in the darkened state $\tau_V(15)$ using the procedure described in 6.5.3.6 at 5 °C, 23 °C and 35 °C.

NOTE The manufacturer may use additional temperatures, provided this information is made available.

5.4.1.4 Photochromic response at moderate light levels (optional)

If the photochromic response at moderate light levels is stated, it shall be determined by measuring the luminous transmittance of the specimen (see 6.5.1) in the darkened state $\tau_V(15)$ using the procedure described in 6.5.3.4 after exposure to the illumination specified in 6.5.2.1 attenuated to an intensity of 30 %.

5.4.2 Polarizing spectacle lenses

When tested by the method described in 6.6, the ratio of the luminous transmittance values of a polarizing spectacle lens, measured parallel and perpendicular to the plane of polarization, shall be greater than 8:1 for categories 2, 3, 4 and shall be greater than 4:1 for category 1.

If there is a marking on the spectacle lens indicating the plane of polarization, then the actual plane of polarization shall not deviate from this marking by more than ± 3°.

5.4.3 Gradient-tinted spectacle lenses

The stated category for gradient-tinted spectacle lenses shall be determined at the design reference point of the spectacle lens.

NOTE It is recommended that gradient tints be ordered by reference to a manufacturer's identification code, name or reference number.

5.5 Resistance to radiation

Following irradiation as specified in 6.7, the relative change in the luminous transmittance τ_V at the design reference point (for photochromic lenses: in the faded state when tested by the methods described in 6.5.3.1 and 6.5.3.2) shall be less than:

- ± 10 % for spectacle lenses of categories 0 and 1;
- ± 20 % for spectacle lenses of categories 2, 3 and 4.

For photochromic spectacle lenses, the photochromic response $\frac{\tau_{V(0)}}{\tau_{V(15)}}$ following irradiation additionally shall be maintained at $\geqslant 1{,}25$ (regardless of the category).

6 Testing

6.1 General

This clause specifies type-test methods for transmittance properties of spectacle lenses.

NOTE For purposes of quality control, etc., alternative test methods may be used if shown to be equivalent.

6.2 Spectral transmittance

The uncertainties of the test methods determining transmittance values shall be:

- 2 % absolute, for transmittance $> 20\%$;
- 10 % relative, for transmittance $\leqslant 20\%$.

These measurement uncertainties shall be based on a confidence level of 95 %.

6.3 Luminous transmittance and relative visual attenuation coefficient (quotient)

The spectral distribution of standard illuminant D 65 as specified in ISO/CIE 10526 and the luminous efficiency of the average human eye for daylight vision as specified in ISO/CIE 10527 shall be used to determine the luminous transmittance, τ_V. When calculating the luminous transmittance, τ_V, from the spectral transmittance $\tau(\lambda)$, the step width shall not exceed 10 nm.

NOTE 1 The product of the spectral distribution of radiation of the standard illuminant D 65 and the luminous efficiency of the average human eye for daylight vision is given in Annex A. Linear interpolation of these values for steps smaller than 10 nm is permitted.

When calculating the relative visual attenuation coefficient (quotient), Q, for signal lights from the spectral transmittance $\tau(\lambda)$, the step width shall not exceed 10 nm.

NOTE 2 The products of the spectral distribution of radiation of the signal lights and of standard illuminant D 65 and the spectral luminous efficiency function for daylight vision are given in Annex A. Linear interpolation of these values for steps smaller than 10 nm is permitted. Requirements for the relative visual attenuation coefficient (quotient) Q for signal lights are given in ISO 14889.

6.4 Ultraviolet transmittance

The ultraviolet transmittance in the spectral range from 280 nm to 380 nm of the uncut finished spectacle lens shall be determined using a spectrophotometer.

The spectrophotometer shall

a) operate over the wavelength range from 280 nm to 380 nm;

b) have a spectral bandwidth (full width at half maximum, FWHM) not exceeding 5 nm;

c) be capable of measuring spectral data at wavelength intervals not greater than 5 nm;

d) be capable of determining spectral transmittance to within 2,0 % absolute for transmittance $>$ 20 %, and to within 10 % relative for transmittance $\leqslant$ 20 %.

When calculating bioactinically-weighted solar ultraviolet transmittance values τ_{SUVB} from 280 nm to 315 nm and τ_{SUVA} from 315 nm to 380 nm, the step width shall not exceed 5 nm and shall be equal to the spectral bandwidth used for the spectral transmittance measurements.

NOTE The spectral functions for the calculation of the bioactinically-weighted solar ultraviolet transmittance values τ_{SUVA} and τ_{SUVB} defined in ISO 13666 are given in Annex B. Linear interpolation of these values for steps smaller than 5 nm is permitted.

6.5 Transmittance properties of photochromic spectacle lenses and photochromic specimens

6.5.1 Test specimens

The test specimens shall be plano spectacle lenses, normally with a reference thickness of 2,0 mm ± 0,1 mm. If a thickness outside this range is used, the thickness shall be stated. After having undergone careful cleaning, each specimen shall be conditioned as described in 6.5.3.1.

NOTE The base curve is not specified but should be recorded.

6.5.2 Apparatus

6.5.2.1 Irradiation source, used to darken photochromic spectacle lens.

The irradiation source (solar simulator) shall approximate as closely as practical the spectral power distribution of solar radiation defined as air mass (AM) $m = 2$ (see [3] or [11]) at an illuminance of 50 000 lx ± 5 000 lx, or when the luminous transmittance for night driving shall be measured, at an illuminance specified in 6.5.3.5.

Testing shall be done with an irradiation source (e.g. a xenon high pressure lamp with filters) that has the specified luminance of 50 000 lx ± 5 000 lx and the irradiance values given in Table 2, at the specimen's position. The intensity of the irradiation source shall be monitored to correct for drifts in the output of the source.

Where testing at 15 000 lx ± 1 500 lx is specified, the irradiance related values in Table 2 shall be multiplied by 0,30.

See Annex C for details of risks associated with solar radiation.

NOTE 1 Care should be taken to ensure that irradiation from the source does not interfere with the transmittance measurements.

NOTE 2 To attenuate the intensity of the irradiation source (solar simulator) for the measurement of the photochromic response of a photochromic spectacle lens at moderate light levels (see 5.4.1.4), a neutral density filter may be used, suitably positioned in the irradiation beam.

Table 2 — Irradiance for testing photochromic spectacle lenses

Wavelength range nm	**Irradiance** W/m^2	**Irradiance tolerance** W/m^2
300 to 340	< 2,5	—
340 to 380	5,6	± 1,5
380 to 420	12	± 3,0
420 to 460	20	± 3,0
460 to 500	26	± 2,6

6.5.2.2 Specimen chamber, to maintain the specimen at the required temperature, 5 °C, 23 °C or 35 °C, to within ± 2 °C during exposure to the solar simulator.

NOTE 1 A water bath may be used to achieve temperature control. Since immersion of the specimen(s) in water reduces the reflectivity of the surfaces, the transmittance values determined using water immersion may require correction to yield the equivalent "air" values. Calibration of the equipment may be checked using a non-photochromic test sample with refractive index within ± 0,01 of the refractive index of the specimen.

NOTE 2 If a water bath is used, in order to avoid modifying the photochromic performance due to water absorption into the lens, care should be taken not to immerse specimens longer than necessary.

6.5.2.3 Spectrophotometer, capable of recording spectral transmittance data from 280 nm to 780 nm within a time span that does not affect the results. Alternatively, the 280 nm to 380 nm range may be measured off line to ensure the performance measurement is not affected by the monitoring light source.

For determining transmittance properties in the darkened state, the spectrophotometer shall

a) have a spectral bandwidth not greater than 5 nm;

b) be capable of measuring spectral data at wavelength intervals not greater than 5 nm;

c) be capable of determining spectral transmittance to within 2,0 % absolute for transmittance > 20 %, and to within 10 % relative for transmittance ⩽ 20 %.

6.5.3 Determination of luminous transmittance

6.5.3.1 Conditioning

Use the procedure specified by the manufacturer in their product technical information to attain the faded state of the lens. If no procedure is specified by the manufacturer, store the specimen(s) in the dark at 65 °C ± 5 °C for 2,0 h ± 0,2 h. Then store the specimen in the dark at 23 °C ± 5 °C until required for testing, at least 12 h.

6.5.3.2 Luminous transmittance in the faded state

After conditioning and before exposing the specimen to any irradiation source, determine the luminous transmittance $\tau_V(0)$ of the specimen in its faded state, using the apparatus described in 6.5.2 with the specimen at a temperature of 23 °C ± 2 °C.

6.5.3.3 Luminous transmittance in the darkened state

While maintaining the specimen temperature at 23 °C ± 2 °C illuminate the specimen with the irradiation source for 15 min ± 0,1 min and determine the luminous transmittance $\tau_V(15)$ of the specimen in the darkened state using the apparatus described in 6.5.2.

6.5.3.4 Luminous transmittance at moderate light levels

When determining the photochromic response at moderate light levels, repeat the procedure described in 6.5.3.1 to 6.5.3.3 at 23 °C ± 2 °C at an illuminance of 15 000 lx ± 1 500 lx with the solar simulator specified in 6.5.2.1.

6.5.3.5 Luminous transmittance for driving at night

After conditioning as described in 6.5.3.1 and while maintaining the specimen temperature at 23 °C ± 2 °C, illuminate the specimen under the conditions described in 6.5.3.4 for 15 min ± 0,1 min. Afterwards, store the specimen at 23 °C ± 2 °C for 60 min ± 1 min either in the dark or under reduced illumination, depending on the manufacturer's instructions. Then determine the luminous transmittance τ_V of the specimen using the apparatus described in 6.5.2.

6.5.3.6 Luminous transmittance at various temperatures

When determining the temperature sensitivity of the specimen(s), repeat the procedure described in 6.5.3.1 to 6.5.3.3 at 5 °C ± 2 °C and 35 °C ± 2 °C.

6.6 Test methods for polarizing spectacle lenses

6.6.1 Mean luminous transmittance

The transmittance value of polarizing lenses shall be determined using unpolarized light or shall be calculated as a mean value of the transmittance values determined for two mutually perpendicular orientations of the polarization plane of the filter.

6.6.2 Ratio of luminous transmittance values

The ratio of the luminous transmittance values parallel and perpendicular to the plane of polarization is determined with radiation polarized parallel and perpendicular to the plane of polarization. For the measurements, a spectrophotometer shall be used in combination with a polarizing medium of known plane of polarization in the ray path.

Before measuring the sample the spectrophotometer beam should be essentially 100 % linearly polarized by the introduction of a suitable polarizing medium and calibrating to 100 %.

6.6.3 Plane of polarization

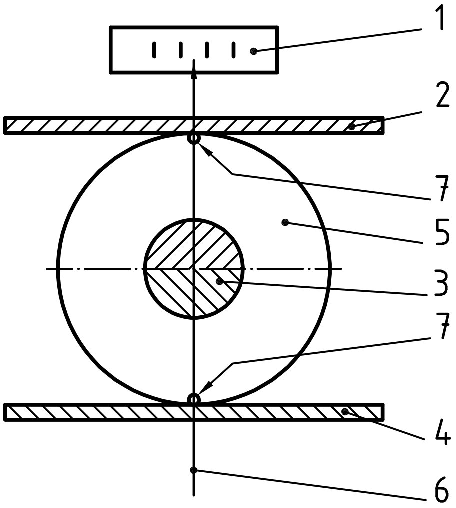
6.6.3.1 General

For the determination of the plane of polarization, a polarizer of known plane of polarization in the light path shall be used, e.g., by the method given in 6.6.3.2 and 6.6.3.3.

6.6.3.2 Apparatus

See Figure 1.

A split field polarizer, cut at + 3° and – 3° angles either side of the horizontal whose top and bottom halves shall be then joined together and glass mounted, capable of being rotated by means of a lever carrying a corresponding pointer. The pointer transverses a scale calibrated in degrees to the left or right of zero. The split fields shall be illuminated from behind by a diffuse light source.



Key

1	scales	5	polarizing spectacle lens
2	top register bar	6	split field rotation lever
3	split field polarizer	7	markings for the polarization plane
4	bottom register bar		

Figure 1 — Principle of an apparatus for the determination of the plane of polarization

6.6.3.3 Procedure

Mount the polarizing spectacle lens on the apparatus and orientate the marking vertically for the plane of polarization, i.e. the front surface towards the split fields on a horizontal register bar, and ensure that the split field appears in the centre of the polarizing spectacle lens by means of vertical adjusters. Move the lever from side to side until the top and bottom halves of the illuminated split-field polarizer appear of equal density when viewed through the lens.

Read off the pointer position to give the deviation in degrees (plus or minus) of the polarizing axis of the lens from the marking direction.

6.7 Determination of resistance to radiation

Expose the front surface of the specimen for 25 h ± 0,1 h to radiation from a xenon lamp at a distance of 300 mm ± 10 mm measured from the axis of the lamp to the nearest point on the specimen(s). Ensure that the angle of incidence of the radiation on the specimen external surface is essentially perpendicular.

Use an ozone-free high-pressure xenon lamp of 450 W nominal power, stabilized at a lamp current of 25 A ± 0,2 A. Burn in new lamps for at least 150 h before use.

NOTE A suitable lamp reference is XBO-450 OFR2).

Carry out the determination using new specimens. Keep the ambient temperature close to the specimen essentially constant at 23 °C ± 5 °C.

7 Information

The following information shall be supplied by the manufacturer or supplier on the package of the lens or in an accompanying document:

a) identification of the finished lens;

b) classification(s) in accordance with Clause 4;

c) category(ies) in accordance with Table 1;

d) reference to this part of ISO 8980, i.e. ISO 8980-3, either on the package or in available literature (documents), if the manufacturer or supplier claims compliance with this part of ISO 8980.

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2) XBO-450 OFR is the trade name of a product supplied by Osram. This information is given for the convenience of users of this International Standard and does not constitute an endorsement by ISO of the product named. Equivalent products may be used if they can be shown to lead to the same results.

Annex A

(normative)

Spectral weighting functions for calculating relative visual attenuation coefficient (quotients)

Table A.1 gives the product of the spectral distribution of radiation of the signal lights (light source: standard illuminant A) and of the standard illuminant D 65 as specified in ISO/CIE 10526 and of the spectral luminous efficiency function of the average human eye for daylight vision as specified in ISO/CIE 10527.

Table A.1 — Product of the spectral distribution of radiation of the signal lights and of standard illuminant D 65 and the spectral luminous efficiency function of the average human eye for daylight vision

Wavelength	$S_{\mathrm{A}\lambda}(\lambda)\cdot\tau_{\mathrm{sign}}(\lambda)\cdot V(\lambda)$				$S_{\mathrm{D65}\lambda}(\lambda)\cdot V(\lambda)$
nm	Red	Yellow	Green	Blue [a]	
380	0	0	0	0,000 1	0
390	0	0	0	0,000 8	0,000 5
400	0	0	0,001 4	0,004 2	0,003 1
410	0	0	0,004 7	0,019 4	0,010 4
420	0	0	0,017 1	0,088 7	0,035 4
430	0	0	0,056 9	0,352 8	0,095 2
440	0	0	0,128 4	0,867 1	0,228 3
450	0	0	0,252 2	1,596 1	0,420 7
460	0	0	0,485 2	2,638 0	0,668 8
470	0	0	0,902 1	4,040 5	0,989 4
480	0	0	1,671 8	5,902 5	1,524 5
490	0	0	2,997 6	7,886 2	2,141 5
500	0	0	5,355 3	10,156 6	3,343 8
510	0	0	9,083 2	13,056 0	5,131 1
520	0	0,181 7	13,018 0	12,836 3	7,041 2
530	0	0,951 5	14,908 5	9,663 7	8,785 1
540	0	3,279 4	14,762 4	7,206 1	9,424 8
550	0	7,518 7	12,468 7	5,780 6	9,792 2
560	0	10,734 2	9,406 1	3,254 3	9,415 6
570	0	12,053 6	6,328 1	1,397 5	8,675 4
580	0,428 9	12,263 4	3,896 7	0,848 9	7,887 0
590	6,628 9	11,660 1	2,164 0	1,015 5	6,354 0
600	18,238 2	10,521 7	1,127 6	1,002 0	5,374 0
610	20,382 6	8,965 4	0,619 4	0,639 6	4,264 8
620	17,654 4	7,254 9	0,296 5	0,325 3	3,161 9
630	13,291 9	5,353 2	0,048 1	0,335 8	2,088 9
640	9,384 3	3,735 2	0	0,969 5	1,386 1
650	6,069 8	2,406 4	0	2,245 4	0,810 0
660	3,646 4	1,441 8	0	1,359 9	0,462 9
670	2,005 8	0,789 2	0	0,630 8	0,249 2
680	1,114 9	0,437 6	0	1,216 6	0,126 0
690	0,559 0	0,219 1	0	1,149 3	0,054 1
700	0,290 2	0,113 7	0	0,712 0	0,027 8
710	0,153 3	0,060 1	0	0,391 8	0,014 8
720	0,074 2	0,029 0	0	0,205 5	0,005 8
730	0,038 6	0,015 2	0	0,104 9	0,003 3
740	0,023 2	0,008 9	0	0,051 6	0,001 4
750	0,007 7	0,003 0	0	0,025 4	0,000 6
760	0,004 5	0,001 7	0	0,012 9	0,000 4
770	0,002 2	0,000 9	0	0,006 5	0
780	0,001 0	0,000 4	0	0,003 3	0
Sum	**100**	**100**	**100**	**100**	**100**

[a] For blue flashing light the spectral distribution for 3 200 K is used instead of standard illuminant A.

Annex B
(normative)

Calculation of solar UV transmittance values

This Annex contains the spectral functions for the calculation of solar UV transmittance values.

For the spectral distribution of solar radiation $E_{S\lambda}(\lambda)$, the values are from reference [11].

These values extend to 295 nm and are interpolated where necessary. Between 280 nm and 290 nm the irradiation values are so low that they can be set to 0 for all practical purposes.

The spectral distribution of the relative spectral effectiveness function for UV radiation $S(\lambda)$ is taken from reference [12].

The complete weighting function for the calculation of the different UV-transmittance values $W_{\lambda}(\lambda)$ is the product of the relative effectiveness function for UV radiation $S(\lambda)$ and the spectral distribution of solar radiation $E_{S\lambda}(\lambda)$:

$$W_{\lambda}(\lambda) = E_{S\lambda}(\lambda) \cdot S(\lambda) \qquad \text{(B.1)}$$

This weighting function is also given in Table B.1.

Table B.1 — Spectral functions for the calculation of solar UV transmittance values and blue-light transmittance

Wavelength λ	Solar spectral irradiance $E_{S\lambda}$	Relative spectral effectiveness function	Weighting function	Blue-light hazard function	Weighting function
nm	$\mathrm{mW/m^2nm}$	$S(\lambda)$	$W_\lambda = E_{S\lambda}S(\lambda)$	$B(\lambda)$	$WB_\lambda = E_{S\lambda}B(\lambda)$
280	0	0,88	0		
285	0	0,77	0		
290	0	0,64	0		
295	$2,09 \times 10^{-4}$	0,54	0,000 11		
300	$8,10 \times 10^{-2}$	0,30	0,024 3		
305	1,91	0,060	0,115		
310	11,0	0,015	0,165		
315	30,0	0,003	0,090		
320	54,0	0,001 0	0,054		
325	79,2	0,000 50	0,040		
330	101	0,000 41	0,041		
335	128	0,000 34	0,044		
340	151	0,000 28	0,042		
345	170	0,000 24	0,041		
350	188	0,000 20	0,038		
355	210	0,000 16	0,034		
360	233	0,000 13	0,030		
365	253	0,000 11	0,028		
370	279	0,000 093	0,026		
375	306	0,000 077	0,024		
380	336	0,000 064	0,022	0,006	2
385	365			0,012	4
390	397			0,025	10
395	432			0,05	22
400	470			0,10	47
405	562			0,20	112
410	672			0,40	269
415	705			0,80	564
420	733			0,90	660
425	760			0,95	722
430	787			0,98	771
435	849			1,00	849
440	911			1,00	911
445	959			0,97	930
450	1 006			0,94	946
455	1 037			0,90	933
460	1 080			0,80	864
465	1 109			0,70	776
470	1 138			0,62	706
475	1 161			0,55	639
480	1 183			0,45	532
485	1 197			0,40	479
490	1 210			0,22	266
495	1 213			0,16	194
500	1 215			0,10	122

Annex C
(informative)

Spectral radiation risks

C.1 Blue-light hazard

If solar radiation on the ground is evaluated with currently used limit values [12] even under extreme illuminance conditions (e.g. snow surfaces) a risk by the blue part of the radiation is not to be expected. Therefore this part of ISO 8980 contains no specification in this respect but opinion is divided whether there could be a risk. In order to allow a correct description of the blue-light attenuation, a definition of the blue-light transmittance is included.

The blue-light hazard function $B(\lambda)$ is taken from reference [12]. Below 400 nm the blue-light hazard function $B(\lambda)$ is extrapolated linearly on a logarithmic scale. The complete weighting function for the calculation of the blue-light transmittance is the product of blue-light hazard function $B(\lambda)$ and the spectral distribution of solar radiation $E_{S\lambda}(\lambda)$:

$$WB_{\lambda}(\lambda) = E_{S\lambda}(\lambda) \cdot B(\lambda)$$

This weighting function is given in Table B.1.

C.2 Infrared risk

If solar radiation on the ground is evaluated with the currently used limit values [12], even under extreme illuminance conditions (e.g. snow surfaces) no risk by the infrared part of radiation is to be expected. Therefore this part of ISO 8980 contains no specification in this respect.

C.3 Ultraviolet risk

Equations for the analytic characterization of ultraviolet skylight [4] as adapted for calculating corneal irradiance [5], show that the largest influence on ocular exposure in temperate regions is the seasonal variation of solar irradiance; this is followed by ground reflectance, and then by time from solar noon [6]. Diffuse sky radiation decreases with increasing altitude [7] [8], and corneal irradiation is nearly constant [6]. Calculated biologically-weighted exposure doses and the corresponding ultraviolet transmittance limits for sunglasses that would keep those doses below a recognized safe limit, for exceptional (greater than plausibly realizable) daily exposure experiences [6] [9], are the bases of the adopted transmittance limits. Further margins of safety, in addition to those implicit in the exceptional exposure experiences, are incorporated.

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