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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 8980-3:2013(E)

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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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The committee responsible for this document is ISO/TC 172, *Optics and photonics*, Subcommittee SC 7, *Ophthalmic optics and instruments*.

This third edition cancels and replaces the second edition (ISO 8980-3:2003), which has been technically revised. In particular, the requirement in 6.3.2 for lenses intended for road use and driving has been amended with an extension of three years for the continued manufacture of existing products.

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*

— *Part 5: Minimum requirements for spectacle lens surfaces claimed to be abrasion-resistant*

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 and mounted pairs, including attenuation of solar radiation.

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;

— products intended for direct observation of the sun, such as for solar-eclipse viewing.

NOTE Optical and geometric requirements for uncut finished spectacle lenses are specified in ISO 8980-1 and ISO 8980-2, and for mounted lenses, in ISO 21987.

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

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

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

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

3 Terms and definitions

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

NOTE 1 For the convenience of the reader, the following definitions have been reproduced from ISO 13666.

NOTE 2 Absorptance, reflectance and transmittance are usually expressed as percentages. The equations in this clause are written in this form. Although the definitions use integrals, in practice summation, typically at 1 nm, 5 nm or 10 nm intervals, is performed to calculate the various transmittances.

3.1
mean UV-A transmittance
τ_{UVA}
mean transmittance between 315 nm and 380 nm

$$\tau_{\mathrm{UVA}} = 100 \times \frac{1}{65\ \mathrm{nm}} \int_{315\ \mathrm{nm}}^{380\ \mathrm{nm}} \tau(\lambda) \cdot \mathrm{d}\lambda\ \%$$

[ISO 13666:2012, definition 15.3.1]

3.2
solar UV-A transmittance
τ_{SUVA}
mean of the spectral transmittance between 315 nm and 380 nm weighted by the solar radiation distribution $E_S(\lambda)$ at sea level, for air mass 2, and the relative spectral effectiveness function for UV radiation $S(\lambda)$

$$\tau_{SUVA} = 100 \times \frac{\int_{315\ \mathrm{nm}}^{380\ \mathrm{nm}} \tau(\lambda) \cdot E_s(\lambda) \cdot S(\lambda) \cdot \mathrm{d}\lambda}{\int_{315\ \mathrm{nm}}^{380\ \mathrm{nm}} E_s(\lambda) \cdot S(\lambda) \cdot \mathrm{d}\lambda} \%$$

Note 1 to entry: The complete weighting function $W(\lambda)$ is the product of $E_S(\lambda)$ and $S(\lambda)$ and is given in Table B.1.

[SOURCE: ISO 13666:2012, definition 15.3.2]

3.3
solar UV-B transmittance
τ_{SUVB}
mean of the spectral transmittance between 280 nm and 315 nm weighted by the solar radiation distribution $E_S(\lambda)$ at sea level, for air mass 2, and the relative spectral effectiveness function for UV radiation $S(\lambda)$

$$\tau_{SUVB} = 100 \times \frac{\int_{280\ \mathrm{nm}}^{315\ \mathrm{nm}} \tau(\lambda) \cdot E_s(\lambda) \cdot S(\lambda) \cdot \mathrm{d}\lambda}{\int_{280\ \mathrm{nm}}^{315\ \mathrm{nm}} E_s(\lambda) \cdot S(\lambda) \cdot \mathrm{d}\lambda} \%$$

Note 1 to entry: The complete weighting function $W(\lambda)$ is the product of $E_S(\lambda)$ and $S(\lambda)$ and is given in Table B.1.

[SOURCE: ISO 13666:2012, definition 15.3.3]

3.4
luminous transmittance
τ_V
ratio of the luminous flux transmitted by the lens or filter to the incident luminous flux

$$\tau_V = 100 \times \frac{\int_{380\ \mathrm{nm}}^{780\ \mathrm{nm}} \tau(\lambda) \cdot V(\lambda) \cdot S_{D65}(\lambda) \cdot \mathrm{d}\lambda}{\int_{380\ \mathrm{nm}}^{780\ \mathrm{nm}} V(\lambda) \cdot S_{D65}(\lambda) \cdot \mathrm{d}\lambda} \%$$

where

$\tau(\lambda)$ is the spectral transmittance of the spectacle lens;

$V(\lambda)$ is the spectral luminous efficiency function for daylight (see ISO 11664-1);

$S_{D65}(\lambda)$ is the spectral distribution of radiation of CIE standard illuminant D65 (see ISO 11664-2).

Note 1 to entry: The spectral values of the product of the spectral radiation distributions $S_{D65}(\lambda)$ of the CIE standard illuminant D65 and the eye's spectral luminous efficiency function $V(\lambda)$ are given in Table A.2.

[SOURCE: ISO 13666:2012, definition 15.4]

3.5
relative visual attenuation coefficient (quotient) for incandescent traffic signal light recognition/detection
Q-value
ratio of the luminous transmittance of a tinted lens for the spectral radiant power distribution of the light emitted by a traffic signal τ_{signal} to the luminous transmittance of the same lens for CIE standard illuminant D65 (τ_V)

$$Q = \frac{\tau_{signal}}{\tau_V}$$

where

τ_{signal} is the luminous transmittance of the lens for the spectral radiant power distribution of the traffic signal light.

Note 1 to entry: *Q*-values can be determined for each of blue, green, amber (yellow) and red signal lights. τ_{signal} is given by the equation:

$$\tau_{signal} = 100 \times \frac{\int_{380\ nm}^{780\ nm} \tau(\lambda) \cdot \tau_S(\lambda) \cdot V(\lambda) \cdot S_A(\lambda) \cdot d\lambda}{\int_{380\ nm}^{780\ nm} \tau_S(\lambda) \cdot V(\lambda) \cdot S_A(\lambda) \cdot d\lambda} \%$$

where

$\tau_S(\lambda)$ is the spectral transmittance of the traffic signal lens;

$S_A(\lambda)$ is the spectral distribution of radiation of CIE standard illuminant A (or 3 200 K light source for blue signal light) (see ISO 11664-2);

Note 2 to entry: The spectral values of the products of the spectral distributions $S_A(\lambda)$ of the illuminant A, the spectral luminous efficiency function $V(\lambda)$ of the eye and the spectral transmittance $\tau_S(\lambda)$ of the traffic signal lens are given in Table A.1, where $E_{Signal}(\lambda)=S_A(\lambda)\times\tau_S(\lambda)$.

Note 3 to entry: Calculations are currently based on the measured values of $E(\lambda)$ for traffic signal lights using incandescent quartz-halogen lamps. They previously used the product $\tau_S(\lambda) \cdot S_A(\lambda)$ of the spectral transmittance of the traffic signal filter and the spectral distribution of radiation of CIE standard illuminant A. Calculations using the values for quartz-halogen lamps and LED signals will give different results

Note 4 to entry: Adapted from ISO 13666:2012, definition 15.5.

3.6
polarizing efficiency
property of a polarizing lens, describing the percentage of the transmitted light that is polarised, defined by the equation

$$P = 100 \times \frac{\tau_{p,max} - \tau_{p,min}}{\tau_{p,max} + \tau_{p,min}} \%$$

where

$\tau_{p,max}$ is the maximum value of **luminous transmittance** as determined with 100% linearly polarised radiation;

$\tau_{p,min}$ is the minimum value of **luminous transmittance** as determined with 100% linearly polarised radiation.

Note 1 to entry: Adapted from ISO 13666:2012, definition 8.1.12.3.

4 Symbols

The symbols for the characteristic luminous transmittances of photochromic lenses are given in Table 1.

Table 1 — Symbols for the characteristic luminous transmittances of photochromic lenses

Symbols	Characteristic luminous transmittances
τ_{V0}	Luminous transmittance in the faded state as reached at (23 ± 2) °C after specified conditioning.
τ_{V1}	Luminous transmittance in the darkened state as reached at (23 ± 2) °C after specified irradiation simulating mean outdoor conditions.
τ_{VW}	Luminous transmittance in the darkened state as reached at (5± 2) °C after specified irradiation simulating outdoor conditions at low temperatures.
τ_{VS}	Luminous transmittance in the darkened state as reached at (35± 2) °C after specified irradiation simulating outdoor conditions at high temperatures.
τ_{VA}	Luminous transmittance in the darkened state as reached at (23 ± 2) °C after specified irradiation simulating reduced light conditions.

5 Classification

Spectacle lenses are classified with respect to transmittance as follows:

a) clear spectacle lenses, having no intended colour (including grey) in transmission;

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.

6 Requirements

6.1 General

The fundamental requirements for uncut finished lenses, including reference to 6.3 in this part of ISO 8980, are in ISO 14889. The requirements shall apply at a temperature of (23 ± 5) °C, and shall apply at the design reference point, unless specified otherwise.

6.2 General transmittance requirements

6.2.1 Tint descriptions, categories, and UV transmittance requirements

Spectacle lenses shall be attributed to one of five tint descriptions or luminous transmittance categories as specified in Table 2, and shall be tested as described in Clause 7.

A spectacle lens intended to have a luminous transmittance τ_V that is in categories 0, 1, 2 and 3 shall have a luminous transmittance at its design reference point that shall not lie outside the limits of the stated category by more than 2 % absolute. For example, a lens intended to have a luminous transmittance of 40 % but actually having a transmittance of 45 % shall comply with the UV requirements of a category 2 lens.

A spectacle lens intended to have a luminous transmittance τ_V that is in category 4 shall have a luminous transmittance τ_V at its design reference point that shall not lie outside the limits of that category by more than 20 % relative to the stated luminous transmittance.

All lenses shall meet the specified UV requirements corresponding to their intended luminous transmittance τ_V in Table 2, but those clear glass 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 2.

NOTE This exclusion applies because some clear crown glass lenses cannot meet the UV-B requirement.

6.2.2 Tolerances on luminous transmittance of tinted lenses

It is recommended that a tint should be ordered by reference to a manufacturer's sample. Such a tint shall not be obviously dissimilar from the tint of the sample and its assessment is not restricted by its luminous transmittance τ_V measured by spectrophotometer.

For a lens ordered by a specific luminous transmittance τ_V shall have a measured τ_V at the design reference point within ± 8 % absolute of that ordered. The tint of the two lenses of a pair should not be obviously dissimilar.

Table 2 — Categories for luminous transmittance and the related permissible transmittance in the ultraviolet solar spectral range

		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}
Tint description	**Luminous transmittance category**	from over %	to %	> 315 nm to 380 nm UV-A	> 280 nm to 315 nm UV-B
Clear or very light tint	0	80,0	100	τ_V	0,05 τ_V
Light tint	1	43,0	80,0	τ_V	0,05 τ_V
Medium tint	2	18,0	43,0	0,5 τ_V	1,0 % absolute or 0,05 τ_V, whichever is greater
Dark tint	3	8,0	18,0	0,5 τ_V	1,0 % absolute
Very dark tint	4	3,0	8,0	1,0 % absolute or 0,25 τ_V, whichever is greater	1,0 % absolute

6.3 Spectral transmittance requirements of spectacle lenses intended for road use and driving

6.3.1 General

Spectacle lenses having a luminous transmittance τ_V less than or equal to 8 % are not intended for road use and driving. This clause therefore does not contain requirements for such lenses.

6.3.2 Spectral transmittance

The spectral transmittance $\tau(\lambda)$ at any wavelength in the range 475 nm to 650 nm shall be not less than 0,2 τ_V.

For a period of three years from the date of publication of this part of ISO 8980, products that are existing at the date of publication of this part of ISO 8980 that satisfy the requirement that the spectral transmittance, $\tau(\lambda)$ at any wavelength in the range 500 nm to 650 nm shall be not less than 0,2 τ_V will be deemed to pass the requirement of this part of ISO 8980.

6.3.3 Daylight use

When using illuminant D65, the luminous transmittance τ_V of spectacle lenses for road use and driving during daylight shall be more than 8 % at the design reference point.

6.3.4 Driving in twilight or at night

Spectacle lenses with a luminous transmittance τ_V less than 75 % shall not be used for road use and driving in twilight or at night. In the case of photochromic spectacle lenses, this requirement applies when tested in accordance with 7.5.3.5.

6.3.5 Relative visual attenuation coefficient (quotient) for recognition/detection of incandescent signal lights

Spectacle lenses shall have a relative visual attenuation coefficient (quotient) Q not less than:

a) 0,8 for Q_{red};

b) 0,6 for Q_{yellow};

c) 0,6 for Q_{green};

d) 0,4 for Q_{blue}.

The relative visual attenuation coefficient (quotient) Q shall be calculated according to 3.5, in accordance with Table A.1.

6.4 Additional transmittance requirements for special types of spectacle lenses

6.4.1 Photochromic spectacle lenses

6.4.1.1 General

Photochromic spectacle lenses are usually attributed to two categories, corresponding to the faded state and to the darkened state. The faded and darkened state transmittances shall be determined according to the method in 7.5. The UV transmittance in both the faded and darkened states shall conform to the values specified for both categories in Table 2.

NOTE It is not required to claim the category of the lens in its darkened state.

6.4.1.2 Photochromic response

When tested by the methods described in 7.5.3.1 to 7.5.3.3, the ratio of the luminous transmittance of a photochromic specimen (see 7.5.1) in its faded state τ_{V0} and, after 15 min irradiation, in its darkened state τ_{V1} shall be at least 1,25, i.e.

$$\frac{\tau_{V0}}{\tau_{V1}} \geq 1{,}25$$

6.4.1.3 Photochromic response at various temperatures

If photochromic temperature influence is stated, it shall be determined by measuring the luminous transmittance of the specimen (see 7.5.1) in the darkened state using the procedure described in 7.5.3.6 at 5 °C (τ_{VW}), 23 °C (τ_{V1}) and 35 °C (τ_{VS}).

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

6.4.1.4 Photochromic response at moderate light levels

If the photochromic response at moderate light levels is stated, it shall be determined by measuring the luminous transmittance of the specimen (see 7.5.1) in the darkened state τ_{VA} using the procedure described in 7.5.3.4 after exposure to the illumination specified in 7.5.2.1 attenuated to an intensity of 30 %.

6.4.2 Polarizing spectacle lenses

6.4.2.1 Individual uncut polarizing lenses

When tested according to the method in 7.6, the polarizing efficiency as calculated in 3.6 shall be > 78 % for luminous transmittance categories 2, 3, 4 and > 60 % for luminous transmittance category 1.

If there is a marking on the spectacle lens indicating the intended direction of horizontal orientation, then the actual plane of transmittance shall be at (90 ± 3)° from this marking.

6.4.2.2 Mounted pairs of polarizing lenses

If the lenses mounted in spectacles are claimed to be polarizing for sun glare attenuation, the lenses shall be fitted in the frame so that their planes of transmission do not deviate from the vertical by more than ± 5º when tested according to the method in 7.6.

6.4.3 Gradient-tinted spectacle lenses

The requirements for gradient-tinted spectacle lenses shall be determined at the design reference point of the spectacle lens. It is recommended that gradient tints be ordered by reference to a manufacturer's sample lens, identification code, name or reference number.

6.5 Resistance to radiation

Following irradiation as specified in 7.7, the absolute change in the luminous transmittance ($\tau_V' - \tau_V$) of the lenses shall be less than or equal to 5 % absolute where τ_V' is the luminous transmittance after irradiation. In addition, the following shall be met:

a) for photochromic filters $\frac{\tau_{V0}}{\tau_{V1}}$ shall be ≥ 1,25;

b) the UV requirements for the initial τ_V shall continue to be satisfied;

c) if originally intended for road use and driving, the requirements of 6.3 shall continue to be satisfied;

d) where a UV transmittance lower (i.e. better) than that specified in Table 2 is claimed, then this transmittance shall continue to be satisfied.

7 Test methods

7.1 General

This clause specifies reference methods for transmittance properties of spectacle lenses.

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

7.2 Spectral transmittance

The uncertainties of the test methods determining transmittance values shall be not greater than:

— 2 % absolute, for transmittance > 20%;

— 1 % absolute, for luminous transmittance ≤ 20%;

— 10 % relative, for UV transmittance of lenses with luminous transmittance ≤ 20%.

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

7.3 Luminous transmittance and relative visual attenuation coefficient (quotient)

7.3.1 The spectral distribution of standard illuminant D65 as specified in ISO 11664-2 and the luminous efficiency of the average human eye for daylight vision (2° observer) as specified in ISO 11664-1 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.

7.3.2 Relative visual attenuation coefficient for signal light recognition/detection [incandescent]. 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. The relevant formula, from ISO 13666, is:

$$Q = \frac{\tau_{\text{signal}}}{\tau_V}$$

where

τ_V is given in 3.4;

τ_{signal} is given in 3.5;

$E_{\text{Signal}}(\lambda) \times V(\lambda)$ for red, yellow, green and blue incandescent lamps are listed in Table A.1.

NOTE For information, $E_{\text{Signal}}(\lambda) \times V(\lambda)$ for red, yellow, green and blue light emitting diode (LED) signals lights are listed in informative Annex D.

7.4 Ultraviolet transmittance

7.4.1 Principle

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.

7.4.2 Apparatus

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 of 5 nm or less.

7.4.3 Calculation

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, for data recorded with fixed (i.e. constant) spectral bandwidths from 2 nm to 5 nm, the step width shall be equal to or less than the bandwidth; for data recorded with varying spectral bandwidth, or for bandwidths smaller than 2 nm, a step width not greater than 2 nm shall be used.

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.

The relevant formulae are given in ISO 13666 and Clause 3.

7.5 Transmittance properties of photochromic spectacle lenses and photochromic specimens

7.5.1 Test specimens

The test specimens shall be plano spectacle lenses, normally with a reference thickness of (2,0 ± 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 7.5.3.1.

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

7.5.2 Apparatus

7.5.2.1 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[4] or[12]) at an illuminance of 50 000 lx ± 5 000 lx, or when the luminous transmittance for night driving shall be measured, at the illuminance specified in 7.5.3.4.

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 3, 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 3 shall be multiplied by 0,30.

See Annex E 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 6.4.1.4), a neutral density filter may be used, suitably positioned in the irradiation beam.

Table 3 — 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

7.5.2.2 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.

7.5.2.3 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 immediately after removal from the irradiation source to ensure the performance measurement is not affected by the measuring beam.

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 of 5 nm or less.

7.5.3 Determination of transmittance

7.5.3.1 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 ± 5) °C for (2,0 ± 0,2) h. Then store the specimen in the dark at (23 ± 5) °C for a minimum of 12 h before testing.

7.5.3.2 Luminous and UV transmittance in the faded state

After conditioning and before exposing the specimen to any irradiation source, determine the luminous transmittance τ_{V0} and the UV transmittance of the specimen in its faded state, using the apparatus described in 7.5.2 with the specimen at a temperature of (23 ± 2) °C.

7.5.3.3 Luminous and UV transmittance in the darkened state

While maintaining the specimen temperature at (23 ± 2) °C illuminate the specimen with the irradiation source for (15 ± 0,1) min and determine the luminous transmittance τ_{V1} and the UV transmittance of the specimen in the darkened state using the apparatus described in 7.5.2.

7.5.3.4 Luminous transmittance at moderate light levels

When determining the photochromic response at moderate light levels, repeat the procedure described in 7.5.3.1 to 7.5.3.3 at (23 ± 2) °C at an illuminance of 15 000 lx ± 1 500 lx and maintain the same relative spectral power distribution with the solar simulator specified in 7.5.2.1.

7.5.3.5 Luminous and UV transmittance for driving in twilight or at night

After conditioning as described in 7.5.3.1 and while maintaining the specimen temperature at (23 ± 2) °C, illuminate the specimen under the conditions described in 7.5.3.4 for (15 ± 0,1) min. Afterwards, store the specimen at (23 ± 2) °C for (60 ± 1) min either in the dark or under reduced illumination, depending on the manufacturer's instructions. Then determine the luminous transmittance τ_V and the UV transmittance of the specimen using the apparatus described in 7.5.2.

7.5.3.6 Luminous and UV transmittance at various temperatures

If the luminous transmittance or photochromic response at a temperature different from 23°C is stated, it shall be determined by the procedure described in 7.5.3.1 to 7.5.3.3 at (5 ± 2) °C and (35 ± 2) °C.

7.6 Test methods for polarizing spectacle lenses

7.6.1 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 plane of transmission of the lens.

7.6.2 Polarizing efficiency

7.6.2.1 Principle

The polarizing efficiency of a polarizing lens is determined with radiation polarized parallel and perpendicular to the plane of transmission. Before measuring the sample the incident beam should be essentially 100 % linearly polarized by the introduction of a suitable polarizing medium and calibrating to 100 %. The spectacle lens or the linear polarizer is rotated to the point of maximum transmittance. At this orientation, the luminous transmittance, $\tau_{p,max}$, is recorded. The spectacle lens or linear polarizer is then rotated 90° and the luminous transmittance, $\tau_{p,min}$, is recorded. The polarizing efficiency shall then be calculated according to 3.6.

7.6.2.2 Spectrophotometer method

For the measurements, a spectrophotometer shall be used in combination with a polarizing medium of known plane of polarization in the light path. The spectral transmittance shall be determined in accordance with 7.2 and 7.3.

7.6.2.3 Broadband method

Select a combination of source of light and filter to give a correlated colour temperature of (6 500 ± 1 000) K (approximating CIE Standard Illuminant D65 in the visible region). Select a detector with approximately the spectral sensitivity of the CIE 2° Standard Observer (ISO 11664-1) and a visible spectral range that is linear to within ± 0,5 %. Collimate the beam of light from the source and insert the linear polarizer and the spectacle lens under test between the collimator and detector.

7.6.3 Plane of transmission

7.6.3.1 General

For the determination of the plane of transmission, a polarizer of known plane of polarization in the light path shall be used, e.g., by the method given in 7.6.3.2 and 7.6.3.3.

7.6.3.2 Apparatus

See Figure 1.

A pair of polarizers are cut to give planes of transmission at a +3° and a – 3° angle about the horizontal. The top and bottom halves of the polarizers shall be then joined together and glass mounted, with the line of the join horizontal to form a split field polarizer. The split-field polarizer shall be capable of being rotated by means of a lever carrying a corresponding pointer. The pointer transverses a scale calibrated in degrees left or right of zero. The split fields shall be illuminated from behind by a diffused light source. Make sure that the top and bottom register bars are long enough to fix a complete spectacle frame parallel to the horizontal axis for measurements of mounted lenses.

7.6.3.3 Procedure for an uncut lens

Mount the lens on the apparatus between the two register bars with the indicating marks aligned along 180° and with its front surface towards the split-field polarizer. Ensure that the split-field appears in the centre of the lens by means of vertical adjusters.

Move the lever from side to side until the top and bottom halves of the illuminated split-field appear of equal luminance when viewed through the lens.

Read off the pointer position to give the deviation in degrees (plus or minus) of the plane of transmission of the lens from the vertical.

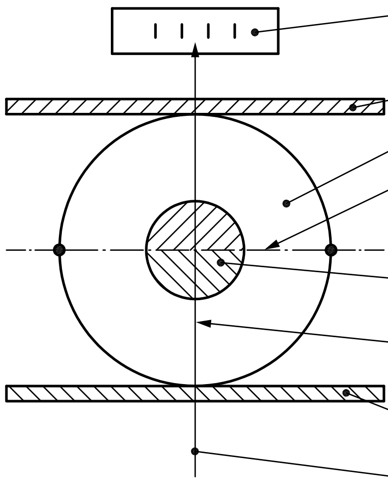
7.6.3.4 Procedure for mounted lenses

Mount the spectacles on the apparatus between the two register bars with the front surface of the lenses towards the split fields. Ensure that the split field appears in the centre of the lens by means of vertical adjusters.

For the left lens, move the lever from side to side until the top and bottom halves of the illuminated split field appear of equal luminance when viewed through the lens.

Read off the pointer position to give the deviation in degrees (plus or minus) of the plane of transmission of the lens from the vertical.

Repeat the procedures for the right lens.



Key

1 scales
2 top register bar
3 split field polarizer
4 bottom register bar
5 polarizing spectacle lens
6 split field rotation lever
7 plane of transmission
8 intended horizontal orientation of lens

Figure 1 — Principle of an apparatus for the determination of the plane of transmission of the lens from the vertical

7.7 Determination of resistance to radiation

7.7.1 Principle

This procedure exposes lenses to 1,44 MJ/m^2 + 0,30 /- 0,00 MJ/m^2 of UV radiation with a spectral distribution simulating sun light from 300 nm to 400 nm. The transmittance of lenses shall be measured according to 7.3 before and after exposure to determine their resistance to radiation.

7.7.2 Reference apparatus

Fused-silica envelope high-pressure xenon lamp. The power of the lamp shall be between 400 W and 500 W, with a preferred value of 450 W.

NOTE Suitable lamp references are XBO-450 W/4 and CSX-450 W/4[1)]

For the operation of the lamp, adhere to the following requirements:

a) new lamps shall be burned in for at least 150 h;

b) the lamp shall not be used after 2000 h of operation;

1) XBO-450 W/4 and CSX-450 W/4 are examples of suitable products available commercially. This information is given for the convenience of users of this International Standard and does not constitute an endorsement by ISO of these products.

c) apply a cut-on filter such as a B270 with a thickness of 4 mm between the lamp and the sample. The spectral transmittance data are given in Annex C. A shift of 5 nm in the transmission at 320 nm is permitted;

d) stabilize the lamp current at (25 ± 0,2) A;

e) the air temperature in the immediate area of the test specimen shall be (28 ± 4) °C.

7.7.3 Procedure using reference apparatus

Expose the front surface of the lens to radiation from the lamp using an irradiation time of (50 ± 0,1) h. The angle of incidence of the radiation on 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 ± 0,1) h at a lamp power of 450 W. The samples shall be allowed to thermally stabilize before measurement of their transmittance properties.

WARNING — Precautions should be taken against potential generation and build-up of ozone.

Apparatus using other power high pressure xenon lamps having different power may be used with the following conditions:

— samples shall be exposed to the radiation as specified in 7.7.1;

— irradiation time shall not be greater than 50 h and not less than 10 h;

— samples shall not be exposed to radiation with wavelengths less than 280 nm;

— air temperature in the immediate area of the test specimen shall be (28 ± 4) °C;

— samples shall be allowed to thermally stabilize prior to measurement of their transmittance properties.

8 Identification

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 5;

c) category(ies) or tint description in accordance with Table 2;

d) reference to this part of ISO 8980, i.e. ISO 8980-3:2013, either on the package or in available literature (documents), if the manufacturer or supplier claims compliance with this part of ISO 8980.

Annex A
(normative)

Spectral data for calculating relative visual attenuation quotients for incandescent signal lights

Table A.1 — Relative spectral distribution of radiation emitted by incandescent signal lights, $E_{Signal}(\lambda)$, weighted by the spectral luminous efficiency function of the average human eye for daylight vision, $V(\lambda)$, as specified in ISO 11664-1

Wavelength λ (nm)	Red $E_{Red}(\lambda) \times V(\lambda)$	Yellow $E_{Yellow}(\lambda) \times V(\lambda)$	Green $E_{Green}(\lambda) \times V(\lambda)$	Blue $E_{Blue}(\lambda) \times V(\lambda)$
380	0,000	0,000	0,000	0,000
385	0,000	0,000	0,000	0,000
390	0,000	0,000	0,000	0,000
395	0,000	0,000	0,000	0,000
400	0,000	0,000	0,000	0,010
405	0,000	0,000	0,000	0,010
410	0,000	0,000	0,000	0,030
415	0,000	0,000	0,000	0,060
420	0,000	0,000	0,000	0,120
425	0,000	0,000	0,000	0,250
430	0,000	0,000	0,000	0,440
435	0,000	0,000	0,010	0,680
440	0,000	0,000	0,020	0,970
445	0,000	0,000	0,030	1,260
450	0,000	0,000	0,050	1,600
455	0,000	0,000	0,080	1,950
460	0,000	0,000	0,120	2,350
465	0,000	0,000	0,180	2,760
470	0,000	0,000	0,270	3,230
475	0,000	0,010	0,380	3,720
480	0,000	0,010	0,540	4,240
485	0,000	0,020	0,740	4,650
490	0,000	0,040	1,020	5,080
495	0,000	0,070	1,410	5,510
500	0,010	0,120	1,910	5,870
505	0,010	0,200	2,610	6,450
510	0,010	0,320	3,430	6,800
515	0,010	0,490	4,370	6,660
520	0,010	0,760	5,320	5,950

Table A.1 *(continued)*

Wavelength λ (nm)	**Red** $E_{Red}(\lambda) \times V(\lambda)$	**Yellow** $E_{Yellow}(\lambda) \times V(\lambda)$	**Green** $E_{Green}(\lambda) \times V(\lambda)$	**Blue** $E_{Blue}(\lambda) \times V(\lambda)$
525	0,020	1,160	6,130	5,150
530	0,020	1,700	6,860	3,960
535	0,020	2,350	7,370	3,370
540	0,020	3,060	7,700	2,650
545	0,020	3,710	7,750	2,320
550	0,020	4,260	7,340	1,940
555	0,020	4,730	6,460	1,460
560	0,030	5,050	5,480	0,970
565	0,040	5,270	4,790	0,660
570	0,080	5,440	4,340	0,360
575	0,230	5,470	3,770	0,280
580	0,670	5,430	3,040	0,200
585	1,640	5,320	2,400	0,220
590	3,320	5,160	1,790	0,240
595	5,400	4,940	1,050	0,230
600	7,320	4,670	0,400	0,230
605	8,750	4,380	0,120	0,180
610	9,350	4,040	0,050	0,130
615	9,320	3,640	0,060	0,100
620	8,950	3,270	0,090	0,060
625	8,080	2,840	0,110	0,070
630	7,070	2,420	0,100	0,070
635	6,100	2,030	0,070	0,160
640	5,150	1,700	0,040	0,210
645	4,230	1,390	0,020	0,430
650	3,410	1,110	0,020	0,540
655	2,690	0,870	0,010	0,420
660	2,090	0,670	0,000	0,320
665	1,570	0,510	0,000	0,210
670	1,150	0,370	0,000	0,140
675	0,850	0,280	0,000	0,260
680	0,640	0,210	0,000	0,300
685	0,470	0,150	0,000	0,320
690	0,330	0,100	0,000	0,300
695	0,240	0,070	0,000	0,230
700	0,180	0,060	0,010	0,180
705	0,130	0,040	0,020	0,130
710	0,090	0,030	0,020	0,100
715	0,070	0,020	0,020	0,070

Table A.1 *(continued)*

Wavelength λ (nm)	**Red** $E_{Red}(\lambda) \times V(\lambda)$	**Yellow** $E_{Yellow}(\lambda) \times V(\lambda)$	**Green** $E_{Green}(\lambda) \times V(\lambda)$	**Blue** $E_{Blue}(\lambda) \times V(\lambda)$
720	0,050	0,010	0,020	0,050
725	0,030	0,010	0,020	0,030
730	0,020	0,010	0,010	0,030
735	0,020	0,010	0,010	0,020
740	0,010	0,000	0,010	0,010
745	0,010	0,000	0,010	0,010
750	0,010	0,000	0,000	0,010
755	0,010	0,000	0,000	0,010
760	0,010	0,000	0,000	0,010
765	0,000	0,000	0,000	0,000
770	0,000	0,000	0,000	0,000
775	0,000	0,000	0,000	0,000
780	0,000	0,000	0,000	0,000

Table A.2 — Product, $S_{D65}(\lambda)\cdot V(\lambda)$, of the spectral distribution of radiation of CIE standard illuminant D65, $S_{D65}(\lambda)$, as specified in ISO 11664-2 and the spectral luminous efficiency function of the average human eye for daylight vision, $V(\lambda)$, as specified in ISO 11664-1

Wavelength λ nm	$S_{D65}(\lambda)\cdot V(\lambda)$
380	0,0001
385	0,0002
390	0,0003
395	0,0007
400	0,0016
405	0,0026
410	0,0052
415	0,0095
420	0,0177
425	0,0311
430	0,0476
435	0,0763
440	0,1141
445	0,1564
450	0,2104
455	0,2667
460	0,3345
465	0,4068
470	0,4945

Table A.2 *(continued)*

Wavelength λ nm	$S_{D65}(\lambda)\cdot V(\lambda)$
475	0,6148
480	0,7625
485	0,9001
490	1,0710
495	1,3347
500	1,6713
505	2,0925
510	2,5657
515	3,0589
520	3,5203
525	3,9873
530	4,3922
535	4,5905
540	4,7128
545	4,8343
550	4,8981
555	4,8272
560	4,7078
565	4,5455
570	4,3393
575	4,1607
580	3,9431
585	3,5626
590	3,1766
595	2,9377
600	2,6873
605	2,4084
610	2,1324
615	1,8506
620	1,5810
625	1,2985
630	1,0443
635	0,8573
640	0,6931
645	0,5353
650	0,4052
655	0,3093
660	0,2315
665	0,1714

Table A.2 *(continued)*

Wavelength λ nm	$S_{D65}(\lambda) \cdot V(\lambda)$
670	0,1246
675	0,0881
680	0,0630
685	0,0417
690	0,0271
695	0,0191
700	0,0139
705	0,0101
710	0,0074
715	0,0048
720	0,0031
725	0,0023
730	0,0017
735	0,0012
740	0,0009
745	0,0006
750	0,0004
755	0,0002
760	0,0001
765	0,0001
770	0,0001
775	0,0001
780	0,0000
Sum	100,0000

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 $E_S(\lambda)$, the values are from reference.[12]

These values extend to 280 nm and are interpolated linearly 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.[13]

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

$$W(\lambda)=E_S(\lambda)\times S(\lambda)$$

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 nm	Solar spectral irradiance $E_s(\lambda)$ mW·m^{-2} nm^{-1}	Relative spectral effectiveness function $S(\lambda)$	Weighting function $W(\lambda) = E_s(\lambda) \times S(\lambda)$	Blue-light hazard function $B(\lambda)$	Weighting function $W_B(\lambda) = E_s(\lambda) \times B(\lambda)$
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		

Table B.1 *(continued)*

Wavelength λ nm	**Solar spectral irradiance** $E_s(\lambda)$ mW·m^{-2} nm^{-1}	**Relative spectral effectiveness function** $S(\lambda)$	**Weighting function** $W(\lambda) = E_s(\lambda) \times S(\lambda)$	**Blue-light hazard function** $B(\lambda)$	**Weighting function** $W_B(\lambda) = E_s(\lambda) \times B(\lambda)$
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
(normative)

Cut-on filter for UV filtering

The radiation emitted by the lamp used in 7.7.3 for the test of resistance to radiation shall be filtered by a cut-on filter with a transmittance curve lying in the wavelength band as specified by the upper and lower limit defined by Table C.1. Transmittance values for wavelengths with cells left blank and values between specified wavelength positions should be calculated by linear interpolation if necessary. The nominal position of the absorption edge of this filter is $T_{46\ \%}$ = 320 nm. A suitable filter for this purpose is a 4 mm thick clear white crown glass B 270.

Table C.1 — Spectral characteristics for filtering the UV radiation for the test of resistance to radiation

Wavelength λ nm	Spectral transmittance (%)		
	lower limit	nominal value	upper limit
280,0	< 0,1	< 0,1	< 0,1
287,0			< 0,1
288,0			0,1
289,0			0,2
290,0			0,3
291,0		< 0,1	0,5
292,0		0,1	0,7
293,0		0,2	1,0
294,0		0,3	1,5
295,0		0,5	2,1
296,0		0,7	2,8
297,0	< 0,1	1,1	3,7
298,0	0,1	1,5	4,9
299,0	0,2	2,1	6,1
300,0	0,3	2,8	7,6
301,0	0,5	3,6	9,3
302,0	0,8	4,7	11,2
303,0	1,1	5,9	13,4
304,0	1,6	7,3	15,6
305,0	2,2	8,9	18,0
306,0	3,0	10,7	20,5
307,0	4,0	12,7	23,2
308,0	5,2	14,9	26,0
309,0	6,6	17,2	28,8
310,0	8,1	19,6	31,7
311,0	9,9	22,1	34,5

Table C.1 *(continued)*

Wavelength λ nm	Spectral transmittance (%)		
	lower limit	nominal value	upper limit
312,0	11,9	24,7	37,4
313,0	14,0	27,4	40,2
314,0	16,3	30,1	42,9
315,0	18,7	32,8	45,7
316,0	21,3	35,5	48,2
317,0	24,0	38,2	50,8
318,0	26,7	41,0	53,3
319,0	29,5	43,5	55,6
320,0	32,3	46,2	57,9
321,0	35,1	48,7	60,0
322,0	37,9	51,1	62,1
323,0	40,8	53,5	64,1
324,0	43,5	55,7	65,9
325,0	46,1	57,8	67,7
326,0	48,7	60,0	69,3
327,0	51,3	61,9	70,9
328,0	53,7	63,7	72,4
329,0	55,9	65,5	73,7
330,0	58,1	67,2	74,9
331,0	60,3	68,7	76,1
332,0	62,3	70,2	77,1
333,0	64,1	71,6	78,2
334,0	65,9	72,9	79,1
335,0	67,6	74,1	79,9
336,0	69,3	75,2	80,8
337,0	70,7	76,3	81,6
338,0	72,1	77,4	82,3
339,0	73,4	78,2	82,9
340,0	74,7	79,1	83,5
341,0	75,8	79,9	84,1
342,0	76,9	80,5	84,6
343,0	77,9	81,3	85,1
344,0	78,9	82,0	85,6
345,0	79,7	82,6	85,9
346,0	80,4	83,2	86,3
347,0	81,3	83,6	86,7
348,0	81,9	84,1	87,0
349,0	82,6	84,5	87,3
350,0	83,2	84,9	87,5

Table C.1 *(continued)*

Wavelength λ nm	Spectral transmittance (%)		
	lower limit	nominal value	upper limit
351,0	83,4	85,5	87,9
352,0	83,6	85,7	88,0
353,0	83,8	86,0	88,2
354,0	84,0	86,4	88,4
355,0	84,2	86,6	88,6
356,0	84,4	86,9	88,8
357,0	84,5	87,1	88,9
358,0	84,7	87,3	89,0
359,0	84,9	87,5	89,2
360,0	85,1	87,6	89,3
361,0	85,3	88,0	89,4
362,0	85,5	88,0	89,5
363,0	85,7	88,2	89,6
364,0	85,8	88,3	89,7
365,0	86,1	88,5	89,8
366,0	86,3	88,5	89,8
367,0	86,4	88,7	89,9
368,0	86,7	88,7	90,0
369,0	86,8	88,8	
370,0	87,0	88,9	

