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Eye and face protection — Test methods —

Part 2: Physical optical properties

Protection des yeux et du visage — Méthodes d'essai —

Partie 2: Propriétés optiques physiques

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Foreword

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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 (see www.iso.org/directives).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committe ISO/TC 94, *Personal safety — Protective protective equipment*, Subcommittee SC 6, *Eye and face protection*.

This first edition of ISO 18526-2, together with ISO 18526-1, cancels and replaces ISO 4854:1981.

A list of all parts in the ISO 18526 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user’s national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

This family of documents comprised of the ISO 16321 series, the ISO 18526 series and the ISO 18527 series was developed in response to the worldwide stakeholders' demand for minimum requirements and test methods for eye and face protectors traded internationally. ISO 4007 gives the terms and definitions for all the various product types. The test methods are given in the ISO 18526 series, while the requirements for occupational eye and face protectors are given in the ISO 16321 series. Eye protectors for specific sports are mostly dealt with by the ISO 18527 series. A guidance document, ISO 19734, for the selection, use and maintenance of eye and face protectors is under preparation.

Eye and face protection — Test methods —

Part 2:
Physical optical properties

1 Scope

This document specifies the reference test methods for determining the physical optical properties of personal eye and face protectors.

This document does not apply to any eye and face protection products for which the requirements standard(s) specifies other test methods.

Other test methods can be used provided they have been shown to be equivalent and include uncertainties of measurement no greater than those required of the reference method.

2 Normative references

The following documents are referred to in such a way that some or all of their content constitutes requirements 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 4007, *Personal protective equipment — Eye and face protection — Vocabulary*

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

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

CIE 15:2019, *Colorimetry*

CIE S 017, *International lighting vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 4007 and CIE S 017 apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

4 Preparatory information

Before testing, refer to the appropriate product's requirements standard for the information needed to apply the tests in this document, for example:

— the number of test samples[1)];

— preparation of test samples;

1) For the purpose of this document, “test sample” is taken to be the object under test, e.g. “ocular”, “lens”, “filter”, or “complete protector” as specified in the requirements standard.

— the selection of test samples (if included in this document);

— any prior conditioning or testing;

— test method (if more than one is included in this document);

— any deviations from the method(s);

— characteristics to be assessed subjectively (if appropriate);

— pass/ fail criteria.

5 General test requirements

Unless otherwise specified, the values stated in this document are expressed as nominal values. Except for temperature limits, values that are not stated as maxima or minima should be subject to a tolerance of ±5 %.

Unless otherwise specified, the ambient temperature for testing should be between 16 °C and 32 °C but if any temperature limits are specified, these should be subject to an accuracy of ±2 °C. Relative humidity should be maintained at (50 ± 20) %.

Unless otherwise specified, the test samples shall be tested at the reference points (for testing) as defined in ISO 4007.

The tests shall be done by trained observers.

For each of the required measurements performed in accordance with this document, a corresponding estimate of the uncertainty of measurement shall be evaluated according to Annex A.

6 Test methods for measuring transmittance — General

6.1 Uncertainty of measurement

Unless otherwise indicated, the measures calculated from spectral transmittance or optical density and the broadband measures of transmittance or optical density shall have uncertainties less than or equal to those given in Table 1.

Table 1 — Uncertainty of measured spectral transmittance and optical density

Spectral transmittance value		Relative uncertainty %	Spectral optical density		Absolute uncertainty
less than %	to %		from	*T* to less than	
100	17,8	±5	0,0	0,7	±0,02
17,8	0,44	±10	0,7	2,4	±0,05
0,44	0,023	±15	2,4	3,6	±0,07
0,023	0,001 2	±20	3,6	4,9	±0,10
0,001 2	0,000 023	±30	4,9	6,6	±0,15
0,000 023	0,000 001 2	±40	6,6	7,9	±0,22
0,000 001 2		±50	7,9		±0,30

The application of uncertainty to compliance is set out in Annex A.

The general methods of evaluating the components of uncertainty are set out in ISO/IEC Guide 98-3. Annex B is a guidance to the sources of uncertainty in spectrophotometry, their evaluation and minimization.

6.2 Reporting compliance

Any compliance statement based on values reported from these test methods shall take into account the uncertainty of measurement as set out in Annex A.

6.3 Applicability

The spectrophotometric method applies to measurement of transmittance regardless of the test sample tested, e.g. filters and frames. Assessment of the uncertainty of measurement shall, if necessary, include the consequences of non-parallel surfaced test samples. Annex C gives the various formulae for calculating UV, luminous and IR transmittances from spectral values in summation form; otherwise, these are the same formulae as in ISO 4007.

6.4 Position and direction of measurement

The location and direction of measurement of transmittance shall be as specified in the relevant product requirement standard. If the measurements are not made normal to the surface of the test sample, then particular attention should be paid to the effects of beam displacement, see Annex B. If the direction of measurement is not specified, then it shall be measured normal to the surface of the test sample at the geometrical centre.

Unless otherwise stated, transmittance is measured as direct transmittance (diffuse component excluded).

The test beam shall be incident normally on the surface and any divergence or convergence of the beam shall not result in an uncertainty of measurement exceeding those in Table 1.

6.5 Wavelength intervals

Spectral measurements and calculations shall be carried out at not more than 5 nm intervals ($\Delta\lambda$ = 5 nm) in the ultraviolet and visible region (180 nm to 780 nm) and not more than 10 nm intervals in the infrared region (780 nm to 3 000 nm). The necessary data for calculations at these intervals are provided in Annex D. If smaller intervals are used then linear interpolation of the Annex D data is appropriate.

6.6 Test report

The spectral transmittances and the associated uncertainties of measurement shall be reported as required in the standard referencing this test method.

7 Luminous transmittance

7.1 Calculations of luminous transmittance from spectral values

Luminous transmittance is calculated as a percentage from the spectral transmittances determined hereafter and with reference to a standard observer and a source or illuminant. For the purposes of this document, all calculations use the CIE 2° standard observer (ISO/CIE 11664-1) and CIE standard illuminant A and/or CIE standard illuminant D65 (ISO 11664-2) and/or a Planckian radiator of distribution temperature 1 900 K. See ISO 4007:2018, 3.10.1.32 and, in this document, C.3.1 and Tables D.2 to D.4.

7.2 Test report

The luminous transmittance(s), the applicable illuminant(s) and/or source(s) and the associated uncertainty of measurement shall be reported as required in the standard(s) referencing these methods.

7.3 Broadband method of measurement of luminous transmittance

7.3.1 Apparatus

The luminous transmittance is measured by using a test apparatus consisting of a light source and a photodetector. The light source shall be a broadband collimated light source with approximately the spectral distribution of a CIE standard illuminant in accordance with ISO 11664-2 in the spectral range 380 nm to 780 nm or other source as specified in the standard referencing this test method. The photodetector shall have a spectral response corresponding to CIE 2° standard observer in accordance with ISO/CIE 11664-1. The photodetector shall be mounted normal to the beam of illumination.

7.3.2 Calibration

The broadband method shall be calibrated by comparison with filters for which the luminous transmittances are known with uncertainties of measurement sufficiently small as to enable the applicable requirement of Table 1 to be met by the test method. The maximum difference in shade number between the test sample and the nearest reference filter shall ensure compliance with Table 1.

7.3.3 Procedure

The luminous transmittance is measured as the ratio of the luminous flux transmitted by the test sample to the incident luminous flux measured with no test sample in the light beam.

If the direction of measurement is not specified, measurement shall be with incident radiation normal to the surface of the test sample. If the position of measurement is not specified, the boxed or geometric centre of the test sample shall be used.

7.3.4 Test reports for luminous transmittance values

The luminous transmittance(s), the applicable source (CIE standard illuminant A or D65 or other source) and the associated uncertainty of measurement shall be reported as required in the standard referencing this test method.

7.4 Measurement of uniformity of luminous transmittance

7.4.1 Unmounted filter covering one eye

7.4.1.1 Test method

Locate the reference point defined in ISO 4007:2018, 3.8.8. Determine a circular area centred on the reference point with diameter d calculated as follows, (see Figure 1):

— for test samples equal to or greater than 50 mm in the vertical dimension at the reference point, $d = (40{,}0 \pm 0{,}5)$ mm;

— for test samples less than 50 mm in the vertical dimension at the reference point, $d = [(h - 10) \pm 0{,}5]$ mm where h is the vertical depth of test sample.

If a 5 mm wide portion around the edge of the test sample intrudes into this circular area, then this intrusion shall be excluded from testing.

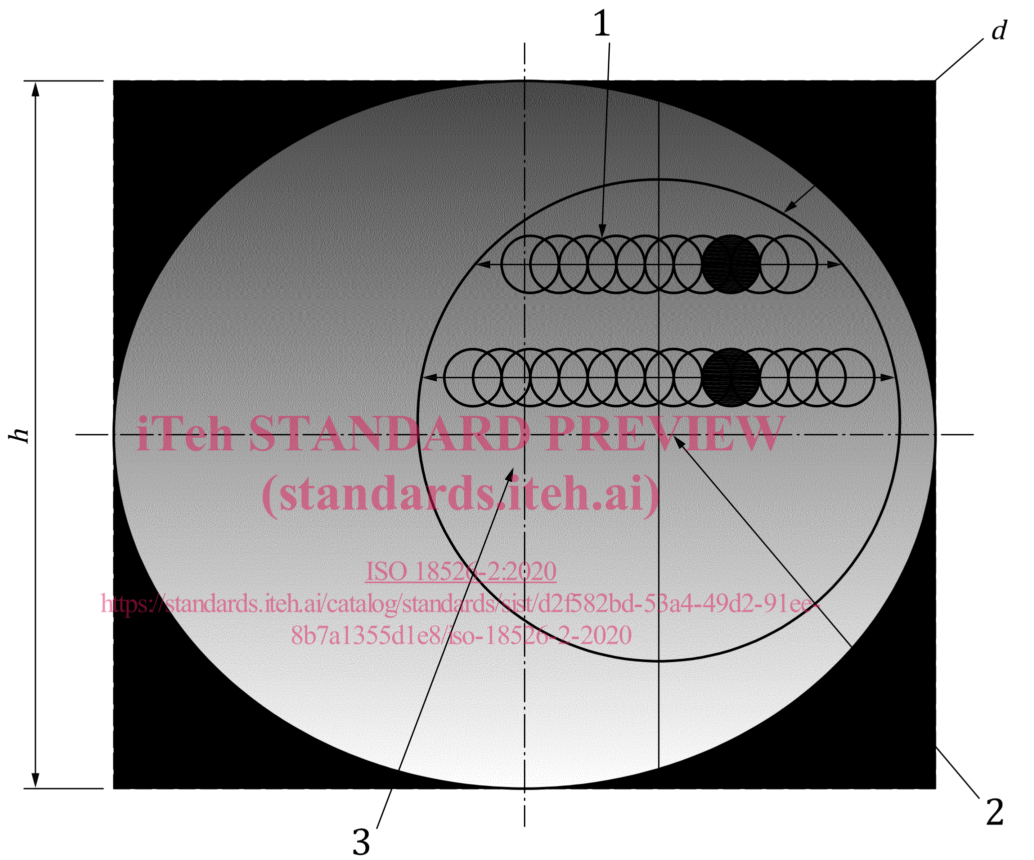
Scan this circular area with beam of light of 5 mm nominal diameter incident normally on the surface of the test sample. Use either white light and a photodetector whose spectral responsivity approximates that of the CIE 2° standard colorimetric observer (ISO/CIE 11664-1) or use a narrow spectral band of light with a maximum spectral energy at (555 ± 25) nm (the spectral sensitivity of the photodetector does not influence the relative measurement). Compensate for any effects of displacement of the light beam by any prismatic effect of the test sample (see B.3.4.1). If necessary to demonstrate compliance, the effects of variation of thickness of the test sample shall be compensated for as in 7.4.1.4.

For test samples with bands or gradients of different luminous transmittance, the requirement for variations in luminous transmittance applies in this circular area but perpendicular to the gradient (see Figure 1). Two example scans perpendicular to the gradient are shown in Figure 1.

Position the test sample and the light beam so that the incident light falls normally on the surface of the test sample at the reference point and parallel to that direction when testing at other locations on the test sample.

Measure and record the maximum value of luminous transmittance $\tau_{v,max}$ and the minimum value of luminous transmittance $\tau_{v,min}$.

Dimensions in millimetres



Key

1 light beam, nominal 5 mm diameter

2 reference point

3 nominated interpupillary distance/2

h vertical depth of the test sample

d diameter of the area under test as specified in 7.4.1.1

Figure 1 — Luminous transmittance uniformity measurement for test samples with bands or gradients of different luminous transmittance

7.4.1.2 Calculations

Calculate the value of ΔF, as a percentage, from the following Formula (1);

$$\Delta F = 100 \times \frac{\left(\tau_{v,max} - \tau_{v,min}\right)}{\tau_{v,max}} \qquad (1)$$

where

$\tau_{v,max}$ is the maximum value of luminous transmittance;

$\tau_{v,min}$ is the minimum value of luminous transmittance.

7.4.1.3 Test report

The value of ΔF as a percentage, the applicable illuminant(s) or source(s) and the associated uncertainty of measurement shall be reported as required in the standard referencing this test method.

7.4.1.4 Method to correct transmittance for variations in thickness of the test sample

The following relation holds between the transmittance and the thickness, t, if multiple reflections within the test sample are neglected:

$$\tau = (1-\rho_1)\cdot(1-\rho_2)\cdot e^{-k\cdot t} \tag{2}$$

where

ρ_1 is the reflectance at the front surface;

ρ_2 is the reflectance of the back surface;

t is the thickness;

k is the absorption coefficient.

The absorption coefficient k can be calculated from the transmittance, τ, for the reference thickness, t, as follows:

$$k = \frac{-\log_e\left[\frac{\tau}{(1-\rho_1)\cdot(1-\rho_2)}\right]}{t} \tag{3}$$

The expected transmittance for a different thickness can then be calculated using Formula (2). Where the refractive index, n, of the medium is known and there is no surface treatment, the reflectance at the interface between the medium and air is given by the following Formula (4):

$$\rho = \left(\frac{n-1}{n+1}\right)^2 \tag{4}$$

7.4.2 Filter covering both eyes

7.4.2.1 Test method

Locate the reference points defined in ISO 4007:2018, 3.8.9 for the nominated interpupillary distance. Determine the two circular areas centred on the reference points with diameter, d, calculated as follows, (see Figure 2):

— for test samples equal to or greater than 50 mm in vertical depth at the reference point, $d = (40{,}0 \pm 0{,}5)$ mm;

— for test samples less than 50 mm in vertical depth at the reference point, $d = [(h - 10) \pm 0{,}5]$ mm, where h is the vertical depth of test sample.

If a 5 mm wide portion around the edge of the test sample intrudes into this circular area, then this intrusion shall be excluded from testing.

Scan this circular area with beam of light of 5 mm nominal diameter incident normally on the surface of the test sample. Use either white light and a photodetector whose spectral responsivity approximates that of the CIE 2° standard colometric observer (ISO/CIE 11664-1) or use a narrow spectral band of light with a maximum spectral energy at (555 ± 25) nm (the spectral sensitivity of the photodetector does not influence the relative measurement). Compensate for any effects of displacement of the light beam by any prismatic effect of the test sample (see B.3.4.1). If necessary to demonstrate compliance, the effects of variation of thickness of the test sample shall be compensated for as in 7.4.1.4.

For a test sample with bands or gradients of different luminous transmittance, the requirement for variations in luminous transmittance applies in this circular area but perpendicular to the gradient. Two example scans perpendicular to the gradient for each of the reference points are shown in Figure 2.

Measure and record the maximum value of luminous transmittance $\tau_{v,max}$ and the minimum value of luminous transmittance $\tau_{v,min}$.

The test sample and the light beam are positioned so that the incident light falls normally on the surface of the test sample at the reference point and parallel to that direction when testing at other locations on the test sample.

