

BS EN ISO 12311:2013

Incorporating corrigenda September 2014 and December 2015



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Personal protective equipment — Test methods for sunglasses and related eyewear

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National foreword

This British Standard is the UK implementation of EN ISO 12311:2013. Together with BS EN ISO 12312-1:2013, it supersedes BS EN 1836:2005 which is withdrawn.

The specification for filters for direct observation of the sun will be EN ISO 12312-2, which is in the course of preparation at the time of publication of this standard.

The UK participation in its preparation was entrusted to Technical Committee PH/2, Eye protection.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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30 September 2014	Implementation of ISO Corrected Text 15 August 2014: second paragraph of subclause 9.7.3.1 has been added
31 December 2015	Implementation of CEN Correction Notice 10 September 2014: EN title page and Foreword updated

English Version

Personal protective equipment - Test methods for sunglasses
and related eyewear (ISO 12311:2013, Corrected version 2014-
08-15)

Équipement de protection individuelle - Méthodes d'essai
pour lunettes de soleil et articles de lunetterie associés (ISO
12311:2013, Version corrigée 2014-08-15)

Persönliche Schutzausrüstung - Prüfverfahren für
Sonnenbrillen und ähnlichen Augenschutz (ISO
12311:2013, korrigierte Fassung 2014-08-15)

This European Standard was approved by CEN on 30 June 2013.

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CEN-CENELEC Management Centre: Avenue Marnix 17, B-1000 Brussels

Foreword

This document (EN ISO 12311:2013) has been prepared by Technical Committee ISO/TC 94 “Personal safety - Protective clothing and equipment” in collaboration with Technical Committee CEN/TC 85 “Eye protective equipment” the secretariat of which is held by AFNOR.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by February 2014, and conflicting national standards shall be withdrawn at the latest by February 2014.

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

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive.

For relationship with EU Directive, see informative Annex ZA, which is an integral part of this document.

According to the CEN-CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

Endorsement notice

The text of ISO 12311:2013, Corrected version 2014-08-15 has been approved by CEN as EN ISO 12311:2013 without any modification.

Annex ZA
(informative)
**Relationship between this European Standard and the Essential
Requirements of EU Directive 89/686/EEC**

This European Standard has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association and supports essential requirements of the EU Directive 89/686/EEC on PPE.

Once this standard is cited in the Official Journal of the European Union under that Directive and has been implemented as a national standard in at least one Member State, compliance with the clauses of this standard, together with the relevant requirements given in the product standards, confers within the limits of the scope of those standards, a presumption of conformity with the corresponding Essential Requirements of that Directive and associated EFTA regulations.

WARNING — Other requirements and other EU Directives may be applicable to the product(s) falling within the scope of this standard

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Foreword

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

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

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

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

This corrected version of ISO 12311:2013 incorporates the following correction:

— the second paragraph of 9.7.3.1 has been added.

Personal protective equipment — Test methods for sunglasses and related eyewear

1 Scope

This International Standard specifies reference test methods for determining the properties of sunglasses given in ISO 12312 (all parts). It is applicable to all sunglasses and related eyewear.

Other test methods may be used if proven to be equivalent.

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 37, *Rubber, vulcanized or thermoplastic — Determination of tensile stress-strain properties*

ISO 48, *Rubber, vulcanized or thermoplastic — Determination of hardness (hardness between 10 IRHD and 100 IRHD)*

ISO 1042:1998, *Laboratory glassware — One-mark volumetric flasks*

ISO 3696:1987, *Water for analytical laboratory use — Specification and test methods*

ISO 4007, *Personal protective equipment — Eye and face protection — Vocabulary*

ISO 8596, *Ophthalmic optics — Visual acuity testing — Standard optotype and its presentation*

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

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

ISO 12312-1:2013, *Eye and face protection — Sunglasses and related eyewear — Part 1: Sunglasses for general use*

ISO/IEC Guide 98-3:2008, *Uncertainty of measurement — Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)*

3 Terms and definitions

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

4 Prerequisites

The following parameters shall be specified prior to testing [see ISO 12312 (all parts)]:

- the number of specimens;
- specimen preparation;
- any conditioning prior to testing;
- characteristics to be assessed subjectively (inappropriate);

— pass/fail criteria.

5 General test requirements

Unless otherwise specified, the values stated in this International Standard are expressed as nominal values. Except for temperature limits, values which are not stated as maxima or minima shall be subject to a tolerance of ± 5 %. Unless otherwise specified, the ambient temperature for testing shall be between 16 °C and 32 °C. Where other temperature limits are specified they shall be subject to an accuracy of ± 1 °C. Relative humidity shall be maintained at (50 ± 20) %.

Unless otherwise specified, the filters shall be tested at the reference points as defined in ISO 4007.

6 Test methods for assessing the construction and materials

6.1 Prior assessment of construction, marking and information

Prior to applying the test methods, a visual inspection shall be carried out with normal or corrected vision, without magnification. Marking and information supplied by the manufacturer and safety data sheets (if applicable) or declaration relevant to the materials used in its construction shall also be assessed.

6.2 Test method for assessment of filter material and surface quality

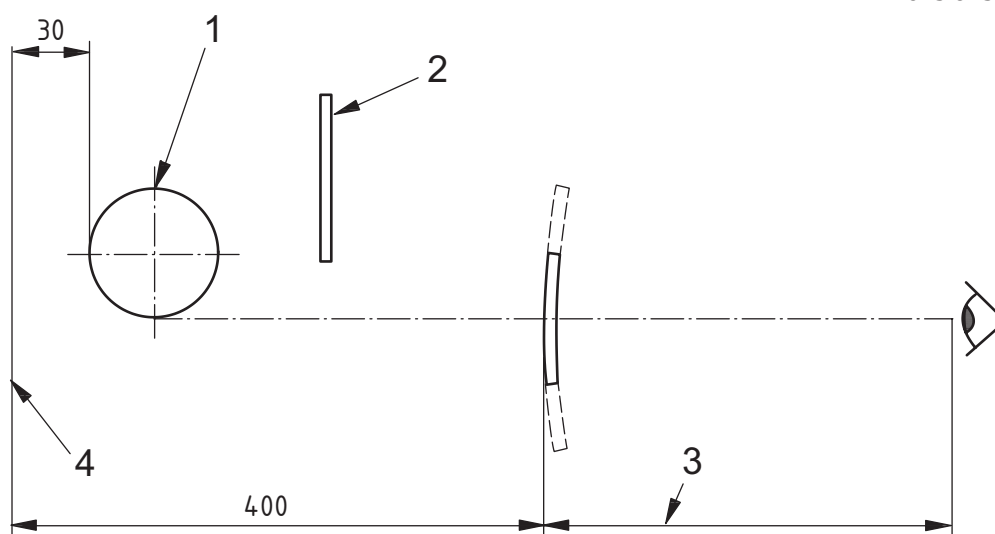
6.2.1 Principle

The quality of the filter material and surface is assessed by visual inspection.

6.2.2 Apparatus

A suitable apparatus is shown in [Figure 1](#).

Dimensions in millimetres



Key

- 1 lamp
- 2 adjustable opaque dull black mask
- 3 near vision distance (≈ 300)
- 4 dull black background (200×360)

Figure 1 — Arrangement of apparatus for assessment of quality of material and surface

6.2.3 Test procedure

Carry out the assessment of the quality of material and surface by visual inspection with the aid of a “light box” or illuminated grid.

NOTE One method of inspection in current use consists of an illuminated grid as a background to be viewed through the filter which is held at various distances from the eye. Another method is to illuminate the filter by means of a fluorescent lamp mounted within a dull black chamber and with the amount of illumination adjusted by means of an adjustable opaque black mask. A suitable arrangement is shown in [Figure 1](#).

6.2.4 Verification and test report

Except for a marginal area 5 mm wide at the edge of the eye protector, any significant defects likely to impair vision in use shall be recorded in the verification and test report.

7 Test methods for measuring spectrophotometric properties

7.1 Measurement of spectral transmittance $\tau(\lambda)$

7.1.1 Spectral transmittance

7.1.1.1 General

Test methods shall be used which have relative uncertainties in spectral transmittance less than or equal to those given in [Table 1](#).

Table 1 — Relative uncertainty of measured spectral transmittance

Spectral transmittance value		Uncertainty %
Less than %	to %	
100	17,8	±2 absolute
17,8	0,44	±10 relative
0,44	0,023	±15 relative
0,023	0,0012	±20 relative
0,0012	0,000023	±30 relative

The general methods of evaluating the components of uncertainty are set out in ISO/IEC Guide 98-3. [Annex A](#) shows how uncertainty of measurement is to be applied in the reporting of results and compliance and [Annex B](#) is a guide to the sources of uncertainty in spectrophotometry, their minimization and evaluation.

The location and direction of measurement of transmittance shall be as specified in ISO 12312-1. If the measurements are not made normal to the surface of the filter, 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 filter when unmounted.

Calculations shall be carried out at not more than 5 nm intervals ($\Delta\lambda = 5$ nm) in the ultraviolet-visible region (280 nm to 780 nm) and not more than 10 nm in the infrared region (780 nm to 2 000 nm). The necessary data at these intervals are provided in [Annexes D, E, F, H](#) and [I](#).

7.1.1.2 Test procedure

Place the filter in order to follow the location and direction of measurement of transmittance as specified in ISO 12312-1.

7.1.2 Calculations of luminous transmittance τ_V

Luminous transmittance is calculated as a percentage from the spectral transmittances and with reference to a standard observer and a source or illuminant. For the purposes of this International Standard all calculations use the CIE 2° Standard Observer [ISO 11664-1 and CIE Standard Illuminant D65 (ISO 11664-2)].

$$\tau_V = 100 \times \frac{\int_{380}^{780} \tau(\lambda) \cdot S_{D65}(\lambda) \cdot V(\lambda) \cdot d\lambda}{\int_{380}^{780} S_{D65}(\lambda) \cdot V(\lambda) \cdot d\lambda} \quad (1)$$

where

λ is the wavelength of the light in nanometres;

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

$V(\lambda)$ is the spectral luminous efficiency function for photopic vision;

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

The values of $S_{D65}(\lambda) \cdot V(\lambda)$ are given in [Annex D](#).

NOTE These calculations are normally carried out as summations and not as integrations. The equivalent summations are provided in [Annex C](#).

7.2 Measurement of uniformity of luminous transmittance

7.2.1 Unmounted filters covering one eye

7.2.1.1 Test method

Locate the defined reference point defined in ISO 4007. Determine a circular area around the reference point with diameter d calculated as follows (see [Figure 2](#)):

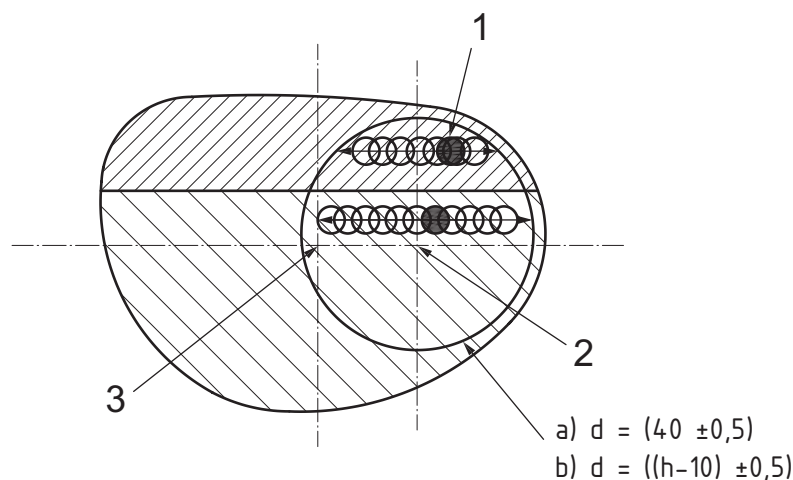
- a) for filters equal to or greater than 50 mm in vertical depth at the reference point, $d = (40,0 \pm 0,5)$ mm;
- b) for filters less than 50 mm in vertical depth at the reference point, $d = [\text{vertical depth of filter (h)} - 10 \pm 0,5]$ mm.

A 5 mm wide portion around the edge of the filter shall be excluded from this circular area.

Scan this circular area with a 5 mm nominal diameter light beam white light or a narrow spectral band with a maximum spectral energy at (555 ± 25) nm and measure the luminous transmittance with a detector whose spectral responsivity approximates that of the CIE 2° Standard Observer (ISO 11664-1). The effects of displacement of the light beam by any prismatic effect of the filter (see [B.3.4.1](#)) shall be compensated for, and variations in thickness shall be corrected as in [Annex L](#).

For filters 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 2](#)). Two example scans perpendicular to the gradient are shown in [Figure 2](#).

Dimensions in millimetres



Key

- 1 light beam 5 mm diameter
- 2 reference point
- 3 geometric or boxed centre

Figure 2 — Luminous transmittance uniformity measurement for filters with bands or gradients of different luminous transmittance

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

Measure and record the maximum value of luminous transmittance τ_{vmax} , and the minimum value of luminous transmittance τ_{vmin} .

7.2.1.2 Calculations

Calculate the value of Δ_F as percentage, from the following formulae:

$$\Delta_F = 100 \times \frac{(\tau_{vmax} - \tau_{vmin})}{\tau_{vmax}} \quad (2)$$

where

τ_{vmax} is the maximum value of luminous transmittance;

τ_{vmin} is the minimum value of luminous transmittance.

7.2.1.3 Test report

Record Δ_F as the uniformity of luminous transmittance.

7.2.2 Mounted filters and unmounted filters covering both eyes

7.2.2.1 Test method

Locate the defined reference points defined in ISO 4007. Define two circular areas around the reference points with diameter d , calculated as follows:

Circular areas are determined around each of these centres with diameters d , calculated as follows:

- a) for filters equal to or greater than 50 mm in vertical depth at the reference point, $d = (40,0 \pm 0,5)$ mm;
- b) for filters less than 50 mm in vertical depth at the reference point, $d = [\text{vertical depth of filter (h)} - 10 \pm 0,5]$ mm.

A 5 mm wide portion around the edge of the filter shall be excluded from this circular area.

Scan this circular area with a 5 mm nominal diameter light beam white light or a narrow spectral band with a maximum spectral energy at (555 ± 25) nm and measure the luminous transmittance with a detector whose spectral responsivity approximates that of the CIE 2° Standard Observer (ISO 11664-1). The effects of displacement of the light beam by the any prismatic effect of the filter (see [B.3.4.1](#)) shall be compensated for and variations in thickness shall be corrected as in [Annex L](#).

For filters with bands or gradients of different luminous transmittance, assessments of variations in luminous transmittance shall be for sections parallel to the line joining the reference points.

Measure and record the value of luminous transmittance τ_{VL} at the left eye reference point and the value of luminous transmittance τ_{VR} at the right eye reference point.

7.2.2.2 Calculations

Divide the absolute difference between the values of the luminous transmittance at the two reference points τ_{VL} and τ_{VR} by the higher value of the luminous transmittance at one of the two reference points and express this ratio, as a percentage Δ_P .

$$\Delta_P = 100 \times \frac{|\tau_{VR} - \tau_{VL}|}{\max(\tau_{VR}, \tau_{VL})} \quad (3)$$

where

τ_{VL} is the value of luminous transmittance at the reference point of the left filter;

τ_{VR} is the value of luminous transmittance at the reference point of the right filter.

EXAMPLE If one filter transmits 38,0 % and the other transmits 40,0 %, then the result is $100 \times (2,0/40,0) = 5,0$ %.

7.2.2.3 Test report

Record the value Δ_P as a percentage.

7.3 Calculation of ultraviolet transmittance

7.3.1 Solar UV-transmittance τ_{SUV}

The calculation of τ_{SUV} (see ISO 4007) as a percentage is:

$$\tau_{SUV} = 100 \times \frac{\int_{280}^{380} \tau(\lambda) \cdot E_s(\lambda) \cdot S(\lambda) \cdot d\lambda}{\int_{280}^{380} E_s(\lambda) \cdot S(\lambda) \cdot d\lambda} = 100 \times \frac{\int_{280}^{380} \tau(\lambda) \cdot W(\lambda) \cdot d\lambda}{\int_{280}^{380} W(\lambda) \cdot d\lambda} \quad (4)$$

where

λ is the wavelength in nanometres;

$\tau(\lambda)$ is the spectral transmittance;

$E_s(\lambda)$ is the solar radiation at sea level for air mass 2; [7]

$S(\lambda)$ is the relative spectral effectiveness function for UV radiation; [8]

$W(\lambda) = E_s(\lambda) \cdot S(\lambda)$ and is the complete weighting function of this product.

The values of $E_s(\lambda)$, $S(\lambda)$ and $W(\lambda)$ are given in [Annex E](#).

7.3.2 Solar UVA-transmittance τ_{SUA}

Solar UVA-transmittance is the result of the mean of the spectral transmittance between 315 nm and 380 nm and appropriate weighting functions.

The calculation of τ_{SUVA} (see ISO 4007) as a percentage is as follows:

$$\tau_{\text{SUVA}} = 100 \times \frac{\int_{315}^{380} \tau(\lambda) \cdot E_{\text{S}}(\lambda) \cdot S(\lambda) \cdot d\lambda}{\int_{315}^{380} E_{\text{S}}(\lambda) \cdot S(\lambda) \cdot d\lambda} = 100 \times \frac{\int_{315}^{380} \tau(\lambda) \cdot W(\lambda) \cdot d\lambda}{\int_{315}^{380} W(\lambda) \cdot d\lambda} \quad (5)$$

where

λ is the wavelength in nanometres;

$\tau(\lambda)$ is the spectral transmittance;

$E_{\text{S}}(\lambda)$ is the solar radiation at sea level for air mass 2; [7]

$S(\lambda)$ is the relative spectral effectiveness function for UV radiation; [8]

$W(\lambda) = E_{\text{S}}(\lambda) \cdot S(\lambda)$ and is the complete weighting function of this product.

The values of $E_{\text{S}}(\lambda)$, $S(\lambda)$ and $W(\lambda)$ are given in [Annex E](#).

7.3.3 Solar UVB-transmittance τ_{SUVB}

Solar UVB-transmittance is the result of the mean of the spectral transmittance between 280 nm and 315 nm and appropriate weighting functions.

The calculation of τ_{SUVB} (see ISO 4007) as a percentage is as follows:

$$\tau_{\text{SUVB}} = 100 \times \frac{\int_{280}^{315} \tau(\lambda) \cdot E_{\text{S}}(\lambda) \cdot S(\lambda) \cdot d\lambda}{\int_{280}^{315} E_{\text{S}}(\lambda) \cdot S(\lambda) \cdot d\lambda} = 100 \times \frac{\int_{280}^{315} \tau(\lambda) \cdot W(\lambda) \cdot d\lambda}{\int_{280}^{315} W(\lambda) \cdot d\lambda} \quad (6)$$

where

λ is the wavelength in nanometres;

$\tau(\lambda)$ is the spectral transmittance;

$E_{\text{S}}(\lambda)$ is the solar radiation at sea level for air mass 2; [7]

$S(\lambda)$ is the relative spectral effectiveness function for UV radiation; [8]

$W(\lambda) = E_{\text{S}}(\lambda) \cdot S(\lambda)$ and is the complete weighting function of this product.

The values of $E_{\text{S}}(\lambda)$, $S(\lambda)$ and $W(\lambda)$ are given in [Annex E](#).

7.4 Calculation of solar blue-light transmittance τ_{sb}

Solar blue-light transmittance is the result of the mean of the spectral transmittance between 380 nm and 500 nm and appropriate weighting functions. The calculation of τ_{sb} (see ISO 4007) as a percentage is as follows:

$$\tau_{sb} = 100 \times \frac{\int_{380}^{500} \tau(\lambda) \cdot E_s(\lambda) \cdot B(\lambda) \cdot d\lambda}{\int_{380}^{500} E_s(\lambda) \cdot B(\lambda) \cdot d\lambda} = 100 \times \frac{\int_{380}^{500} \tau(\lambda) \cdot W_B(\lambda) \cdot d\lambda}{\int_{380}^{500} W_B(\lambda) \cdot d\lambda} \quad (7)$$

where

λ is the wavelength in nanometres;

$\tau(\lambda)$ is the spectral transmittance;

$E_s(\lambda)$ is the solar radiation at sea level for air mass 2; [7]

$B(\lambda)$ is the blue-light hazard function; [9]

$W_B(\lambda) = E_s(\lambda) \cdot B(\lambda)$ and is the complete weighting function of this product.

The values of $E_s(\lambda)$, $B(\lambda)$ and $W_B(\lambda)$ are given in [Annex E](#).

7.5 Calculation of solar IR transmittance τ_{SIR}

The calculation of solar IR transmittance τ_{SIR} (see ISO 4007) as a percentage is obtained by integration between the limits 780 nm and 2 000 nm as follows:

$$\tau_{SIR} = 100 \times \frac{\int_{780}^{2000} \tau(\lambda) \cdot E_s(\lambda) \cdot d\lambda}{\int_{780}^{2000} E_s(\lambda) \cdot d\lambda} \quad (8)$$

where

λ is the wavelength in nanometres;

$\tau(\lambda)$ is the spectral transmittance;

$E_s(\lambda)$ is the spectral distribution of solar radiation at sea level for air mass 2. [7]

The values of $E_s(\lambda)$ are given in [Annex F](#).

7.6 Measurement of absolute spectral reflectance $\rho(\lambda)$

The test methods to be used shall have relative uncertainties in spectral reflectance less than or equal to those given in [Table 2](#). The angle of incidence is to be $\leq 17^\circ$

Table 2 — Relative uncertainty of measured spectral reflectance

Spectral reflectance value		Uncertainty %
Less than %	to %	
100	2,5	±5 % relative
2,5		±10 % relative

If measurements are made without the use of an integrating sphere, care shall be taken to ensure that all the reflected light is collected since the beam reflected from a curved surface will be divergent or convergent and part of it may fall outside the detector. See Reference[10] for guidance.

7.7 Absolute luminous reflectance ρ_V

The calculation of ρ_V as a percentage is obtained by the ratio of the luminous flux reflected by the filter Φ_R to the incident flux Φ_I as follows:

$$\rho_V = 100 \times \frac{\Phi_R}{\Phi_I} = 100 \times \frac{\int_{380}^{780} \rho(\lambda) \cdot V(\lambda) \cdot S_{D65}(\lambda) \cdot d\lambda}{\int_{380}^{780} V(\lambda) \cdot S_{D65}(\lambda) \cdot d\lambda} \quad (9)$$

where

λ is the wavelength in nanometres;

$\rho(\lambda)$ is the spectral reflectance of the filter at wavelength λ ;

$V(\lambda)$ is the relative sensitivity of the human eye as defined in ISO 11664-1;

$S_{D65}(\lambda)$ is the spectral energy distribution of CIE Standard Illuminant D65 as defined in ISO 11664-2.

The values of $S_{D65}(\lambda) \cdot V(\lambda)$ are given in [Annex D](#).

7.8 Calculation of relative visual attenuation quotient for signal light detection Q_{signal}

The quotient of signal detection has the following relationship of τ_{signal} and τ_v

$$Q_{\text{signal}} = \frac{\tau_{\text{signal}}}{\tau_v} \quad (10)$$

where

$$\tau_v = 100 \times \frac{\int_{380}^{780} \tau(\lambda) \cdot S_{\text{D65}}(\lambda) \cdot V(\lambda) \cdot d\lambda}{\int_{380}^{780} S_{\text{D65}}(\lambda) \cdot V(\lambda) \cdot d\lambda} \quad (11)$$

and

$$\tau_{\text{signal}} = 100 \times \frac{\int_{380}^{780} \tau(\lambda) \cdot E_{\text{signal}}(\lambda) \cdot V(\lambda) \cdot d\lambda}{\int_{380}^{780} E_{\text{signal}}(\lambda) \cdot V(\lambda) \cdot d\lambda} \quad (12)$$

where

λ is the wavelength in nanometres;

$\tau(\lambda)$ is the spectral transmittance;

$V(\lambda)$ is the relative sensitivity of the human eye as defined in ISO 11664-1;

$S_{\text{D65}}(\lambda)$ is the spectral energy distribution of CIE Standard Illuminant D65 as defined in ISO 11664-2;

$E_{\text{signal}}(\lambda)$ is the spectral energy distribution of the red, yellow, green and blue traffic signals.

The values of $S_{\text{D65}}(\lambda) \cdot V(\lambda)$ are given in [Annex D](#) and the values of $E_{\text{signal}}(\lambda) \cdot V(\lambda)$ for incandescent signals are given in [Annex H](#) and for LED signals in [Annex I](#).

7.9 Wide angle scatter

7.9.1 Principle

A hazemeter is used to measure the amount of light which deviates from an incident beam by being scattered forward when the beam passes through a specimen, compared to the amount scattered by the test instrument and the amount transmitted by the specimen.

7.9.2 Apparatus

7.9.2.1 Incandescent light source approximating CIE Standard Illuminant A (ISO 11664-2).

7.9.2.2 Hazemeter with integrating sphere, light trap, photodiode and reflectance standard (see [Figure 3](#)) as follows:

- a) The integrating sphere shall have:
- 1) a total port area not exceeding 4,0 % of the total internal reflecting area of the sphere;
 - 2) the entrance and exit ports separated by at least 170°;
 - 3) the exit port subtending 8° at the centre of the entrance port;
 - 4) the photodiode $(90 \pm 10)^\circ$ from the entrance port; and
 - 5) all internal surfaces (including the reflectance standard for the exit port) covered with a substance of high reflectance for wavelengths between 380 nm and 780 nm.

NOTE 1 A barium sulfate paint may be suitable.

- b) The light trap shall have a reflectance of less than 0,1 %.
- c) The photodiode shall provide proportional measurements of the radiant flux to within 1 % of the incident flux, across the range of intensity used within the test.
- d) These components shall be arranged so that the irradiating beam shall:
- 1) have the axis of the beam passing through the centre of the entrance and exit ports;
 - 2) be unidirectional, with no ray of the beam deviating from the direction of the axis of the beam by greater than 3°;
 - 3) when there is no specimen obstructing the beam, have a circular cross-section at the exit port, while the diameter of the exit port shall exceed the diameter of the irradiating beam so that there is an annular zone around the beam subtending $(1,3 \pm 0,1)^\circ$ at the entrance port;
 - 4) when a specimen covers the entrance port, not form an angle greater than 8° between the axis of the beam and the normal to the surface of that specimen; and
 - 5) when there is no specimen obstructing the beam, be completely absorbed by the light trap (if used).

NOTE 2 Although wide angle scatter measurements are made most commonly by the use of a hazemeter, a spectrophotometer can be used, provided that it meets the geometric and spectral requirements of this subclause. A spectrophotometer is necessary when the luminous transmittance, τ_v of the filter is below about 15 %.

7.9.3 Specimen

The size of the specimen can vary with the size of the entrance port and the surface curvature of the integrating sphere. The specimen shall be large enough to completely cover the entrance port but shall be small enough to be tangential to the wall of the integrating sphere.

7.9.4 Test procedure

Carry out the procedure as follows.

- a) Measure the incident light (τ_1) without the specimen in position, without the light trap in position and with the reflectance standard in position.
- b) Measure the total light transmitted by the specimen (τ_2) with the specimen in position, without the light trap in position and with the reflectance standard in position.
- c) Measure the light scattered by the instrument (τ_3) without the specimen in position, with the light trap in position, and without the reflectance standard in position.
- d) Measure the light scattered by the instrument and specimen (τ_4) with the specimen in position, with the light trap in position and without the reflectance standard in position.

- e) Repeat step (b) so that four readings are obtained, rotating the specimen between readings by 90°.
- f) Repeat step (d) so that four readings are obtained at the same positions as in step (e).

7.9.5 Calculation

The following shall be calculated:

The average values of τ_2 and τ_4 ($\bar{\tau}_2$ and $\bar{\tau}_4$).

- a) The total transmittance from the formula:

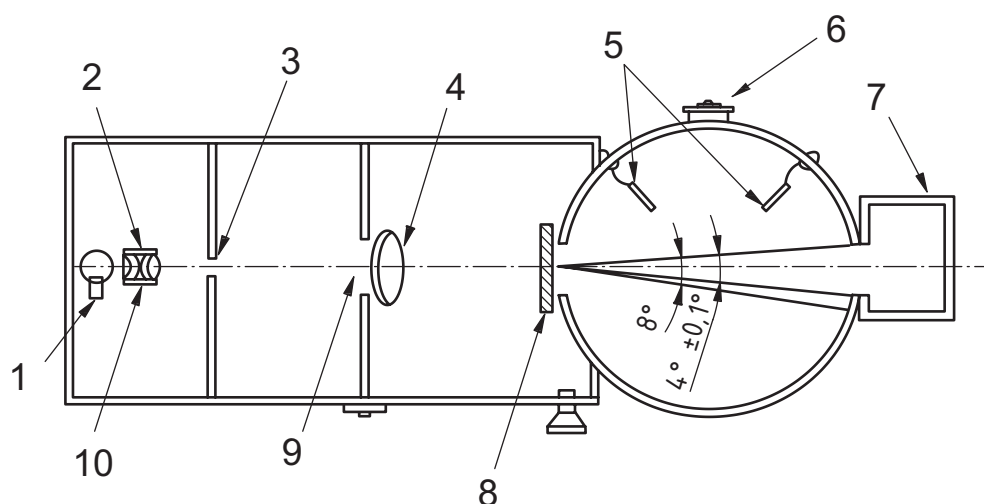
$$\tau_t = \frac{\bar{\tau}_2}{\tau_1} \quad (13)$$

- b) The scattered light from the formula:

$$\tau_d = \left[\bar{\tau}_4 - \tau_3 \cdot \frac{\bar{\tau}_2}{\tau_1} \right] / \tau_1 \quad (14)$$

- c) The wide angle scatter, expressed as a percentage, from the formula:

$$\text{wide angle scatter} = \frac{\tau_d}{\tau_t} \times 100 \quad (15)$$



Key

- 1 source
- 2 condenser
- 3 entrance window
- 4 lens
- 5 baffles
- 6 photocell
- 7 light trap
- 8 specimen
- 9 aperture
- 10 filter

Figure 3 — Diagram of typical equipment for the measurement of wide angle scatter

7.9.6 Test report

Report the wide angle scatter value.

7.10 Polarizing filters

7.10.1 Plane of transmission

7.10.1.1 Apparatus

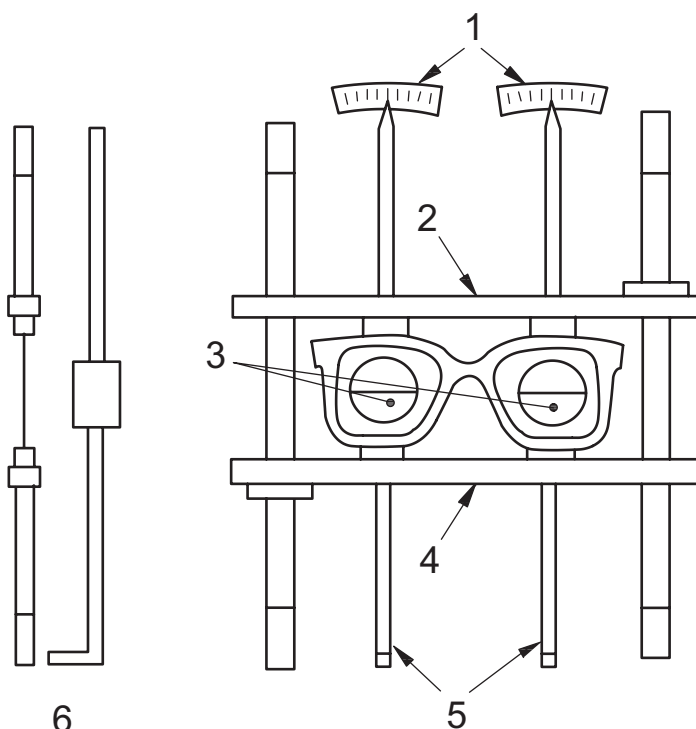
7.10.1.1.1 Pair of individually mounted split field polarizers cut to give planes of transmission at a + 3° and a - 3° angle about the horizontal, or the prescribed axis. The top and bottom halves of the polarizers shall be joined together and glass mounted, with the line of the join horizontal or perpendicular to the prescribed axis. The polarizers 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 (see [Figure 3](#)).

7.10.1.2 Test procedure

Mount the sunglass on the apparatus (see [Figure 4](#)), with the front towards the split fields on a horizontal register bar and ensure that the split field appears in the centre of the filter by means of vertical adjusters and that the pantoscopic angle and the face form angle are 'as worn'.

For the left filter, 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 filter.

Read off the pointer position to give the deviation in degrees (plus or minus) of the plane of transmission of the filter from the horizontal or the prescribed orientation. Repeat the procedures for the right filter.



Key

- 1 scales
- 2 top register bar
- 3 split-field polarizers
- 4 bottom register bar
- 5 split-field rotation lever
- 6 side view

Figure 4 — Apparatus for the determination of the plane of transmission

7.10.2 Polarizing efficiency

7.10.2.1 Principle

The luminous transmittance for visible light is measured with plane polarized light with the plane of oscillation set to provide the maximum and the minimum transmittance of the lens. This can be done by a spectrophotometric method and calculation method (the reference method) or, in a broadband method using a detector with the sensitivity of the human eye (peak at 555 nm) and a source equivalent to CIE Standard Illuminant D65.

7.10.2.2 Test procedure for the spectrophotometric method

Carry out the procedure as follows.

- a) Mount the linear polarizers with their planes of transmission parallel in the reference and sample beams of the spectrophotometer. The linear polarizers shall have a polarization at least one order of magnitude better than the requirement being tested against [e.g. if the requirement for the filter is a polarizing efficiency of 80 % (9:1) then the linear polarizers shall have an efficiency of at least 97,5 % (90:1)].
- b) Mount the polarizing filter in the spectrophotometer.

- c) With the spectrophotometer wavelength set to (550 ± 5) nm, rotate the filter to the point of maximum transmittance.
- d) At this orientation, measure the spectral transmittances, $\tau_{\text{pmax}}(\lambda)$ in the range 380 nm to 780 nm at 5 nm intervals.
- e) Rotate the filter 90° and measure the spectral transmittances, $\tau_{\text{pmin}}(\lambda)$, in the same way.
- f) Calculate the luminous transmittances for the two conditions in the same way as set out in 7.2 providing two values of luminous transmittance, τ_{pmax} and τ_{pmin} .

$$\tau_{\text{pmax}} = 100 \times \frac{\int_{380}^{780} \tau_{\text{pmax}}(\lambda) \cdot S_{\text{D65}}(\lambda) \cdot V(\lambda) \cdot d\lambda}{\int_{380}^{780} S_{\text{D65}}(\lambda) \cdot V(\lambda) \cdot d\lambda} \quad (16)$$

$$\tau_{\text{pmin}} = 100 \times \frac{\int_{380}^{780} \tau_{\text{pmin}}(\lambda) \cdot S_{\text{D65}}(\lambda) \cdot V(\lambda) \cdot d\lambda}{\int_{380}^{780} S_{\text{D65}}(\lambda) \cdot V(\lambda) \cdot d\lambda} \quad (17)$$

where

- λ is the wavelength in nanometres;
- $V(\lambda)$ is the relative sensitivity of the human eye as defined in ISO 11664-1;
- $S_{\text{D65}}(\lambda)$ is the spectral energy distribution of CIE Standard Illuminant D65 as defined in ISO 11664-2.

- g) Calculate the polarizing efficiency P as a percentage as given in ISO 4007.

$$P = 100 \times \frac{\tau_{\text{pmax}} - \tau_{\text{pmin}}}{\tau_{\text{pmax}} + \tau_{\text{pmin}}} \quad (18)$$

NOTE Polarization is sometimes described by the polarizing ratio (R_{pol}).

$$R_{\text{pol}} = \frac{\tau_{\text{pmax}}}{\tau_{\text{pmin}}} : 1 \quad (19)$$

7.10.2.3 Test procedure for the broadband method

A light source and filter combination to give a correlated colour temperature of $(6\,500 \pm 1\,000)$ K (approximating CIE Standard Illuminant D65 in the visible region, see ISO 11664-2) is used to produce a collimated beam of diameter (5 ± 2) mm to illuminate the filter under test at the reference point defined in ISO 12312-1. The light is polarized using the same specification linear polarizer as in 7.10.2.2 a). The light is incident on a detector with approximately the spectral sensitivity of the CIE 2° Standard Observer (ISO 11664-1). The responsivity of the detector shall be linear to within $\pm 0,5\%$ in the range of illuminance measured.

The filter or the linear polarizer is rotated to the point of maximum transmittance. At this orientation, the luminous transmittance, τ_{pmax} , is recorded. The filter or linear polarizer is then rotated 90° and the luminous transmittance, τ_{pmin} , is recorded.

7.11 Photochromic filters

7.11.1 Light source(s) to approximate the spectral distribution of solar radiation for air mass $m = 2$ for testing

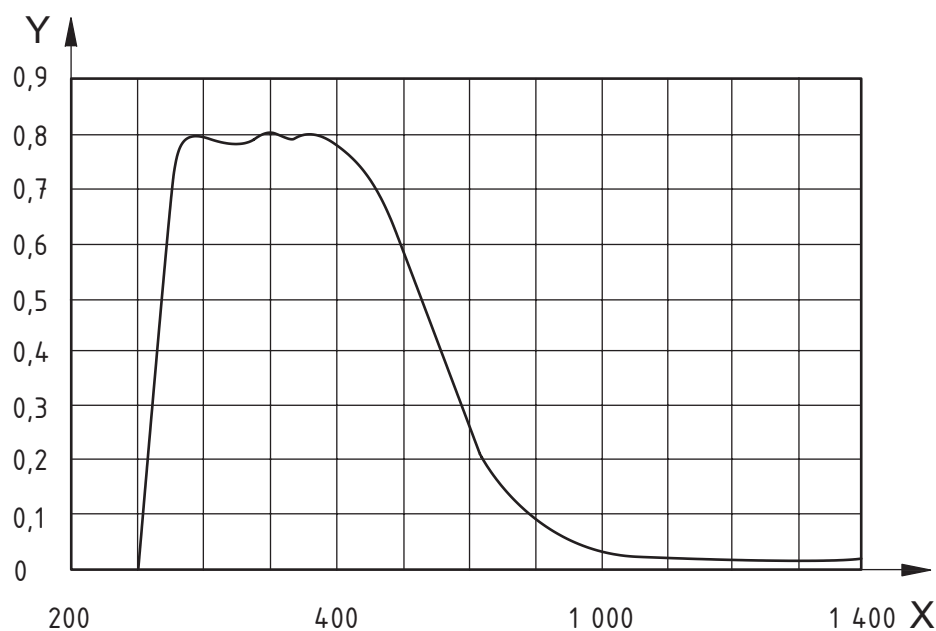
Testing shall be done with a Xenon high pressure lamp with filters chosen so that the specified illuminance of $(50\,000 \pm 5\,000)$ lx and the irradiance values (with permitted tolerances) given in [Table 3](#) are reached.

Table 3 — Irradiance for testing the darkened state of photochromic lenses

Wavelength range nm	Irradiance $\text{W}\cdot\text{m}^{-2}$	Tolerance $\text{W}\cdot\text{m}^{-2}$
300-340	< 2,5	-
340-380	5,6	$\pm 1,5$
380-420	12,0	$\pm 3,0$
420-460	20,0	$\pm 3,0$
460-500	26,0	$\pm 2,6$

7.11.1.1 Radiation source using one lamp

Use an ozone free high pressure xenon arc lamp, a heat absorbing filter and a cut-on filter as specified in [Figure 5](#).



Key

X wavelength (nm)

Y transmittance (absolute value)

Figure 5 — Spectral transmittance of the combination of the heat absorbing filter and the cut-on filter for the measurement of photochromic lenses

This transmittance curve can be achieved using, for example, a clear white crown glass, e.g. B 270 with a thickness of 5 mm and a heat absorbing filter e.g. a Schott KG 2 with a thickness of 3 mm or a Pittsburgh 2043 of 2 mm thickness¹⁾.

7.11.1.2 Radiation source using two lamps

This is done in order to approximate as closely as possible the spectral distribution of solar radiation for air mass $m = 2$, and may be more closely approximated with the use of two ozone free high pressure xenon arc lamps. The radiation of the two lamps is superimposed by means of a semi-transparent mirror. If different filtering is used in front of the two lamps, the solar spectrum can be approximated more closely than with one lamp.

The principle may be expanded by the use of more than two lamps in order to even better approximate the solar spectrum in the relevant spectral ranges.

7.11.2 Conditioning for luminous transmittance in the faded state

Unless the manufacturer specifies a different procedure to reach the faded state in the information supplied with the product, photochromic filters shall be conditioned by the following procedure.

- a) Store filters in the dark at $(65 \pm 5) ^\circ\text{C}$ for $(2 \pm 0,2)$ h.
- b) Store filters in the dark at $(23 \pm 5) ^\circ\text{C}$ for at least 12 h.
- c) Expose filters to $(15\,000 \pm 1\,500)$ lx at $(23 \pm 1) ^\circ\text{C}$ for 15 min using a source similar to the one described in [7.11.1](#).
- d) Store filters in the dark at $(23 \pm 1) ^\circ\text{C}$ for 60 min.

7.11.3 Measurement

7.11.3.1 Principle

Most photochromic materials respond to normal room lighting and all measurements should therefore be made in absence of extraneous light. Care should be taken to ensure that the radiation used for the measurements does not cause darkening or bleaching of the sample.

The surface temperature of the filter shall be maintained within $\pm 1 ^\circ\text{C}$ of the nominated temperature (see [Table 4](#)).

Measurements may be carried out in a water bath. However, immersion of the specimen in water reduces the refractive index change and, therefore, the reflectance at the filter surface, thereby increasing the measured transmittance relative to the transmittance values that would be measured in air. The transmittance values determined using water immersion shall be corrected to provide the equivalent air values. Calibration of the equipment can be checked using a reference sample with a refractive index differing by not more than $\pm 0,01$ from the refractive index of the filter under test.

7.11.3.2 Faded state

Measure spectral transmittance from 280 nm to 780 nm (or to 2 000 nm if IR is included) according to [7.1](#).

For the requirements specified in ISO 12312-1, calculate the luminous transmittance in the faded state, τ_{V0} in accordance with [7.1](#). These requirements are the solar ultraviolet transmittances ([7.3.1](#) to [7.3.3](#)),

1) Schott KG 2 and B270 are trade names of products supplied by SCHOTT AG and Pittsburgh 2043 is the trade name of a product supplied by Corning INC. This information is given for the convenience of users of this document 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.

the solar blue-light transmittance (see 7.4), the relative visual attenuation quotients for signal light detection, Q_{red} , Q_{yellow} , Q_{green} and Q_{blue} and, if required, the solar infrared transmittance (see 7.5).

7.11.3.3 Darkened states

The characteristic luminous transmittance values of photochromic filters are defined in ISO 4007 and, unless otherwise stated, are determined for the conditions given in Table 4.

Where testing at 15 000 lx is specified, the irradiance values and the permissible tolerances of these values are those given in Table 3, but multiplied by a factor 0,3.

Table 4 — Measurement conditions for the different characteristic luminous transmittance values

Characteristic luminous transmittance value	Surface temperature of the test specimen °C	Illuminance at the surface of the sample lx
τ_{V0}	23 ± 1	0 Faded state
τ_{V1}	23 ± 1	50000 ± 5000

The requirements specified in ISO 12312-1 shall be measured and calculated from the spectral transmittance values measured in the darkened state (τ_{V1}) after 15 minutes' irradiance with $(50\,000 \pm 5\,000)$ lx at (23 ± 1) °C. These requirements are the solar ultraviolet transmittances (see 7.3.1 to 7.3.3), the solar blue-light transmittance (see 7.4), the relative visual attenuation quotients for signal light detection, Q_{red} , Q_{yellow} , Q_{green} and Q_{blue} , and, if required, the solar infrared transmittance (see 7.5).

8 Test methods for measuring optical properties

8.1 Test method for spherical, astigmatic and prismatic refractive powers

8.1.1 Principle

Spherical, astigmatic and prismatic refractive powers of lenses or complete sunglasses are measured by means of a telescope method (reference method). This method requires a relatively wide measurement field. Therefore difficulties can appear in applying this method to filters which exhibit irregular distributions of optical powers across the field of measurement. In such cases the method described in 8.3 can be used for a spatially resolved determination of optical powers.

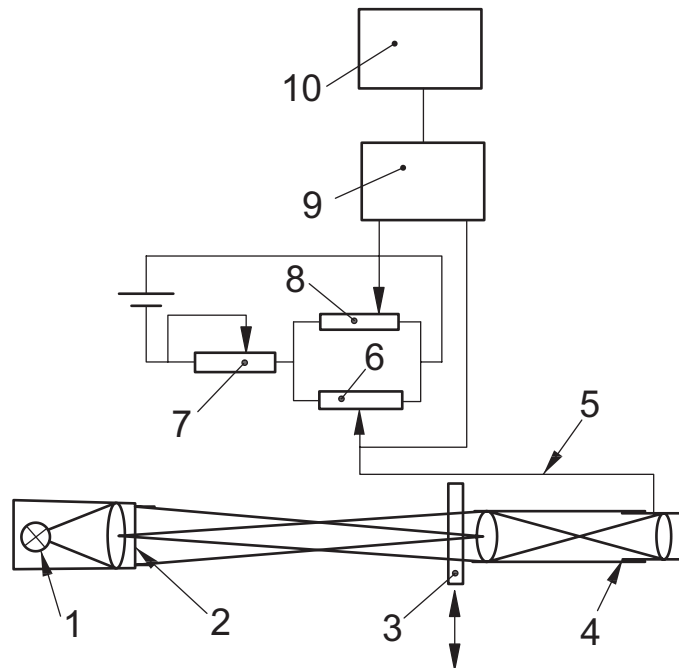
NOTE The recommendations given are for reference. Alternative designs that can be demonstrated to produce results that are equivalent to those obtained with the reference method may also be used. For example, a focimeter can be used for the measurement of those optical properties for which equivalent results can be achieved compared with the telescope method.

8.1.2 Apparatus

8.1.2.1 Electronic recording of visual assessment as shown in Figure 6.

NOTE A mechanical indication of eyepiece movement is also possible.

Figure 6 gives a schematic drawing of the telescope set-up. In this test the re-focusing distance of the telescope's eyepiece is taken as a measure for the optical power of an inserted test object. The set-up shown uses an electronic recording for measurement. Usually the position for the sharp image is assessed visually. This technique may be replaced by means of digital image processing.



Key

- 1 lamp
- 2 telescope target
- 3 sample
- 4 telescope
- 5 re-focusing
- 6 displacement sensor
- 7 calibration
- 8 zero point
- 9 digital voltmeter
- 10 computer

Figure 6 — Schematics of the telescope set-up

8.1.2.2 Telescope with an aperture of nominally 20 mm and a magnification between 10× and 30×, fitted with an adjustable eyepiece incorporating a reticle. The focusing adjustment has a scale of refractive power capable of calibration of the telescope by using the methods as described in [Annex K](#) or by utilizing any other applicable method delivering the same precision.

8.1.2.3 Illuminated target, consisting of a black plate incorporating the cut-out pattern shown in [Figure 7](#), behind which is located a light source of adjustable luminance with a condenser, if necessary, to focus the magnified image of the light source on the telescope objective.

The large annulus of the target has an outer diameter of $(23,0 \pm 0,1)$ mm with an annular aperture of $(0,6 \pm 0,1)$ mm. The small annulus has an inner diameter of $(11,0 \pm 0,1)$ mm with an annular aperture of $(0,6 \pm 0,1)$ mm. The central aperture has a diameter of $(0,6 \pm 0,1)$ mm. The bars are nominally 20 mm long and 2 mm wide with a nominal 2 mm separation.

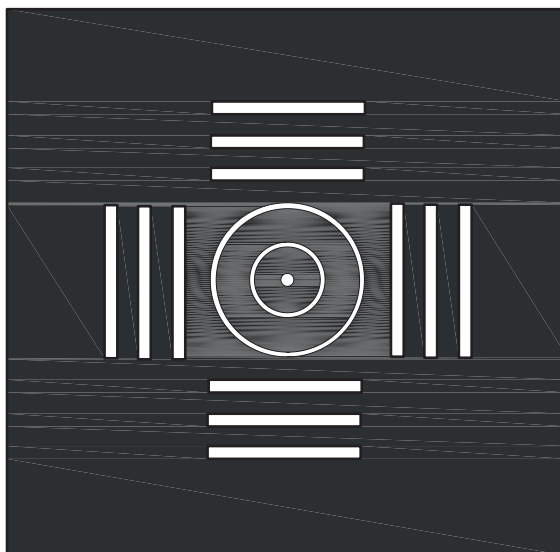


Figure 7 — Telescope target (dimensions are given in [8.1.2.3](#))

8.1.2.4 Filter, with its maximum transmittance in the green part of the spectrum, which can be used to reduce chromatic aberration.

8.1.3 Calibration of the apparatus

The telescope shall be calibrated to achieve an uncertainty of measurement less than or equal to $0,01 \text{ m}^{-1}$. This can be accomplished by using the method of variable distance (see [Annex K](#)) or by using calibration lenses, e.g. lenses that have positive and negative spherical refractive powers of $0,06 \text{ m}^{-1}$, $0,12 \text{ m}^{-1}$ and $0,25 \text{ m}^{-1}$ (tolerance $\pm 0,01 \text{ m}^{-1}$).

8.1.4 Test procedure

8.1.4.1 General

Carry out the procedure as follows.

The telescope and illuminated target are placed on the same optical axis ($4,60 \pm 0,02$) m apart.

The observer shall focus the reticule and the target and align the telescope to obtain a clear image of the pattern. This setting is regarded as the zero point of the focusing scale of the telescope. The telescope shall be aligned so that the central aperture of the target is imaged on the centre of the cross-line graticule. This setting is regarded as the zero point of the prism scale.

The filter is positioned in front of the telescope mounted in the as-worn position as specified by the manufacturer. Measurements of spherical and astigmatic power shall be taken using the procedures specified in [8.1.4.2](#). If during measurement using the telescope a doubling or other aberration of the image is observed, then the filter can either be classified as defective or subjected to further examination using the method described in [8.3](#).

For the positioning of the unmounted filter the following cases can apply.

- a) Filter covering one eye:
 - 1) when the as-worn position is specified by the manufacturer, the positioning is as specified;