

Australian/New Zealand Standard™

# Eye and face protection—Sunglasses and fashion spectacles

## Part 2: Test methods



## **AS/NZS 1067.2:2016**

This Joint Australian/New Zealand Standard was prepared by Joint Technical Committee CS-053, Sunglasses. It was approved on behalf of the Council of Standards Australia on 21 July 2016 and by the New Zealand Standards Approval Board on 6 September 2016.

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## Australian/New Zealand Standard™

# Eye and face protection—Sunglasses and fashion spectacles

## Part 2: Test methods

Originated in Australia as part of AS 1067—1971.  
Previous and first New Zealand edition part of AS/NZS 1067:2003.  
Revised in part and redesignated as AS/NZS 1067.2:2016.

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PREFACE

This Standard was prepared by the Joint Standards Australia/Standards New Zealand Committee CS-053, Sunglasses and fashion spectacles, to supersede, in part, AS/NZS 1067:2003, *Sunglasses and fashion spectacles*.

The objective of this Standard is to specify test methods for sunglasses and fashion spectacles (including replacement filters) in accordance with AS/NZS 1067.1:2016.

This Standard is identical with, and has been reproduced from ISO 12311:2013, *Personal protective equipment—Test methods for sunglasses and related eyewear*.

As this Standard is reproduced from an International Standard, the following applies:

- (a) In the source text ‘this International Standard’ should read ‘this Australian/New Zealand Standard’.
- (b) A full point substitutes for a comma when referring to a decimal marker.

References to International Standards should be replaced by references to Australian or Australian/New Zealand Standards, as follows:

| Reference to International Standard |                                                                  | Australian/New Zealand Standard |                                                           |
|-------------------------------------|------------------------------------------------------------------|---------------------------------|-----------------------------------------------------------|
| ISO                                 |                                                                  | AS/NZS                          |                                                           |
|                                     |                                                                  | 1337                            | Personal eye protection—Eye and face protection           |
| 4007                                | Personal protective equipment—Eye and face protection—Vocabulary | 1337.0                          | Part 0: Vocabulary (ISO 4007:2012, MOD)                   |
| 12312                               | Eye and face protection—Sunglasses and related eyewear           | 1067                            | Eye and face protection—Sunglasses and fashion spectacles |
| 12312-1                             | Part 1: Sunglasses for general use                               | 1067.1                          | Part 1: Requirements                                      |

Only normative references that have been adopted as Australian or Australian/New Zealand Standards have been listed.

The terms ‘normative’ and ‘informative’ have been used in this Standard to define the application of the annex to which they apply. A ‘normative’ annex is an integral part of a Standard, whereas an ‘informative’ annex is only for information and guidance.

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## AUSTRALIAN/NEW ZEALAND STANDARD

**Eye and face protection—Sunglasses and fashion spectacles****Part 2:  
Test methods****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  $\pm 5$  %. 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  $\pm 1$  °C. Relative humidity shall be maintained at  $(50 \pm 20)$  %.

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

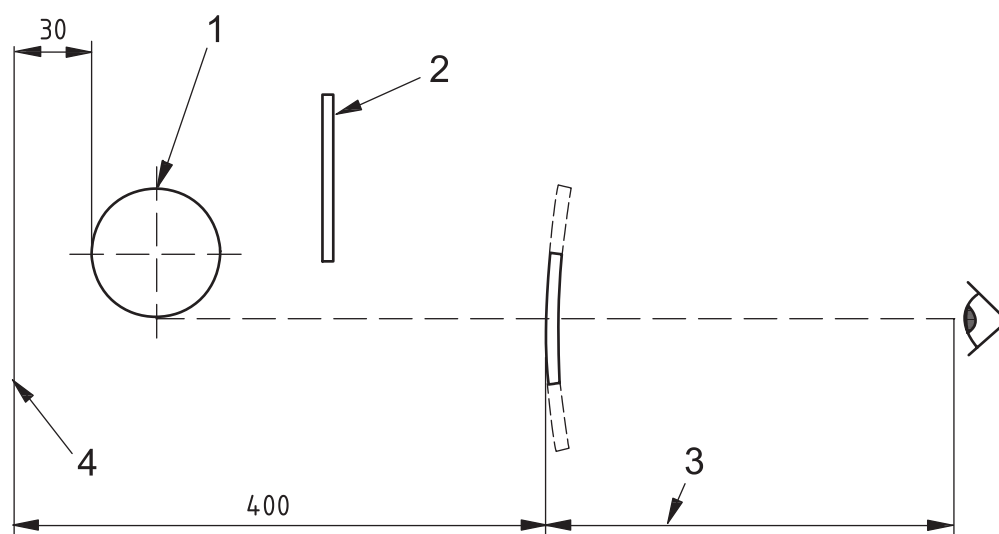
#### 6.2.1 Principle

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 ( $\approx 300$ )
- 4 dull black background ( $200 \times 360$ )

**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<br>% |
|------------------------------|----------|------------------|
| 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 $\tau_V$

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

$\lambda$  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](#)):

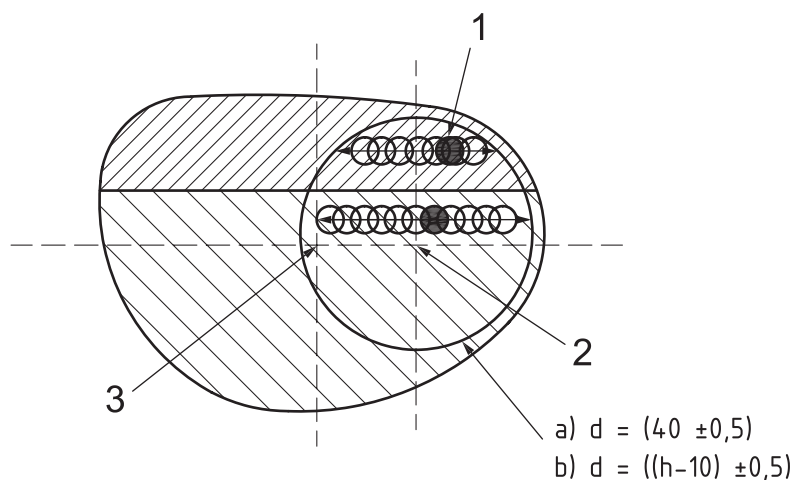
- for filters equal to or greater than 50 mm in vertical depth at the reference point,  $d = (40,0 \pm 0,5)$  mm;
- for filters less than 50 mm in vertical depth at the reference point,  $d = [\text{vertical depth of filter (h)} - 10 \pm 0,5]$  mm.

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  $(555 \pm 25)$  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

- light beam 5 mm diameter
- reference point
- 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  $\tau_{vmax}$ , and the minimum value of luminous transmittance  $\tau_{vmin}$ .

### 7.2.1.2 Calculations

Calculate the value of  $\Delta_F$  as percentage, from the following formulae:

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

where

$\tau_{vmax}$  is the maximum value of luminous transmittance;

$\tau_{vmin}$  is the minimum value of luminous transmittance.

### 7.2.1.3 Test report

Record  $\Delta_F$  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  $(555 \pm 25)$  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  $\tau_{VL}$  at the left eye reference point and the value of luminous transmittance  $\tau_{VR}$  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  $\tau_{VL}$  and  $\tau_{VR}$  by the higher value of the luminous transmittance at one of the two reference points and express this ratio, as a percentage  $\Delta_P$ .

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

where

$\tau_{VL}$  is the value of luminous transmittance at the reference point of the left filter;

$\tau_{VR}$  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  $\Delta_P$  as a percentage.

## 7.3 Calculation of ultraviolet transmittance

### 7.3.1 Solar UV-transmittance $\tau_{SUV}$

The calculation of  $\tau_{SUV}$  (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

$\lambda$  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 $\tau_{SUA}$

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  $\tau_{\text{SUVA}}$  (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

$\lambda$  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 $\tau_{\text{SUVB}}$

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  $\tau_{\text{SUVB}}$  (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

$\lambda$  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 $\tau_{sb}$

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  $\tau_{sb}$  (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

$\lambda$  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 $\tau_{SIR}$

The calculation of solar IR transmittance  $\tau_{SIR}$  (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

$\lambda$  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 E](#).

#### 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<br>% |
|----------------------------|------|------------------|
| 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 $\rho_V$

The calculation of  $\rho_V$  as a percentage is obtained by the ratio of the luminous flux reflected by the filter  $\Phi_R$  to the incident flux  $\Phi_I$  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

$\lambda$  is the wavelength in nanometres;

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

$V(\lambda)$  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 $Q_{\text{signal}}$

The quotient of signal detection has the following relationship of  $\tau_{\text{signal}}$  and  $\tau_v$

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

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

$\lambda$  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,  $\tau_V$  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 ( $\tau_1$ ) 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 ( $\tau_2$ ) 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 ( $\tau_3$ ) 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 ( $\tau_4$ ) 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  $\tau_2$  and  $\tau_4$  ( $\bar{\tau}_2$  and  $\bar{\tau}_4$ ).

- a) The total transmittance from the formula:

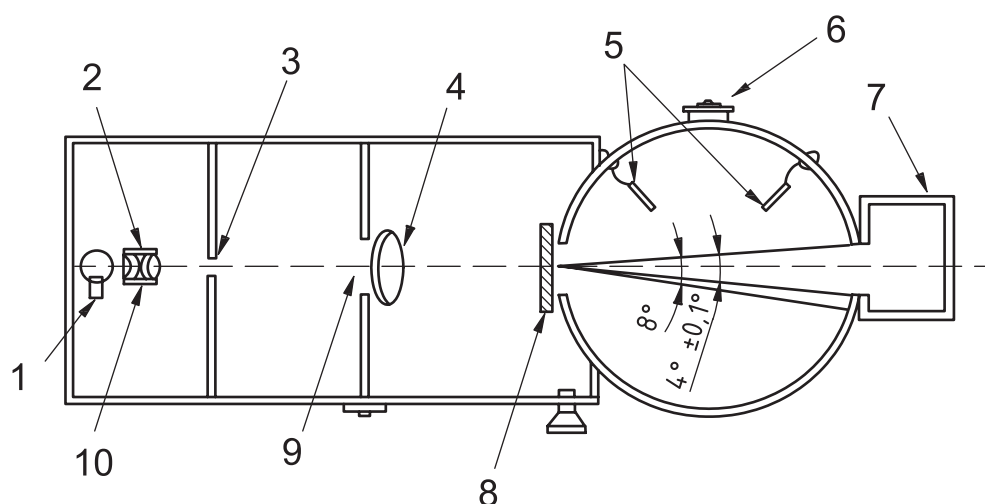
$$\tau_t = \frac{\bar{\tau}_2}{\tau_1} \quad (13)$$

- 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

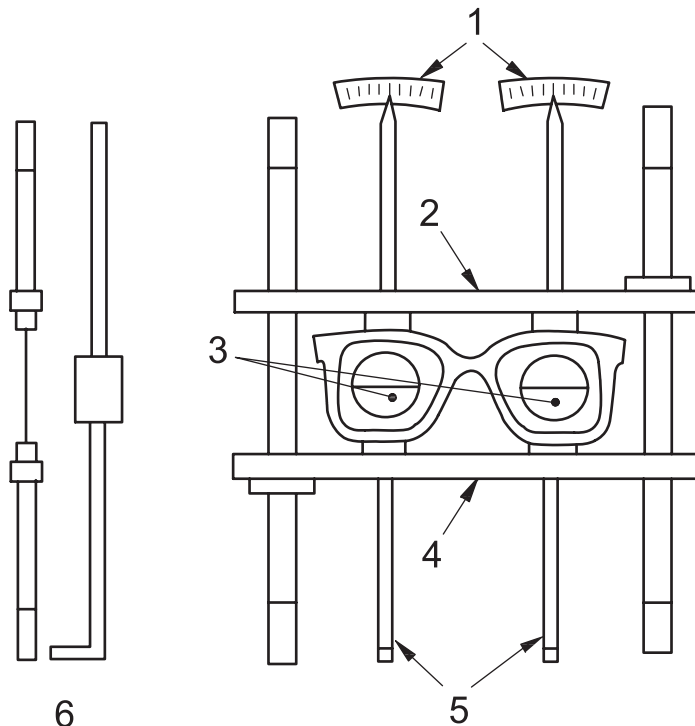
**7.10.1.1.1 Pair of individually mounted split field polarizers** cut to give planes of transmission at a  $+3^\circ$  and a  $-3^\circ$  angle about the horizontal, or the prescribed axis. The top and bottom halves of the polarizers shall be joined together and glass mounted, with the line of the join 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  $(550 \pm 5)$  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  $90^\circ$  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,  $\tau_{\text{pmax}}$  and  $\tau_{\text{pmin}}$ .

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

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

where

$\lambda$  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 ( $R_{\text{pol}}$ ).

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

### 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  $(5 \pm 2)$  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,  $\tau_{\text{pmax}}$ , is recorded. The filter or linear polarizer is then rotated  $90^\circ$  and the luminous transmittance,  $\tau_{\text{pmin}}$ , 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

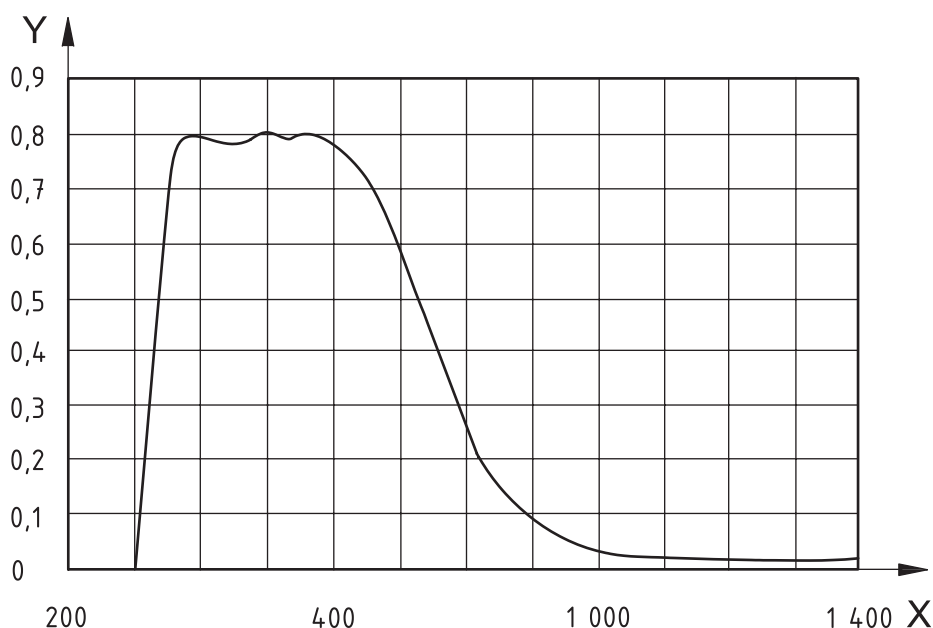
Testing shall be done with a Xenon high pressure lamp with filters chosen so that the specified illuminance of  $(50\,000 \pm 5\,000)$  lx and the irradiance values (with permitted tolerances) given in [Table 3](#) are reached.

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

| Wavelength range<br>nm | Irradiance<br>$\text{W}\cdot\text{m}^{-2}$ | Tolerance<br>$\text{W}\cdot\text{m}^{-2}$ |
|------------------------|--------------------------------------------|-------------------------------------------|
| 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 thickness<sup>1)</sup>.

#### 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,  $\tau_{V0}$  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,  $Q_{\text{red}}$ ,  $Q_{\text{yellow}}$ ,  $Q_{\text{green}}$  and  $Q_{\text{blue}}$  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<br>°C | Illuminance at the surface of the sample<br>lx |
|---------------------------------------------|------------------------------------------------|------------------------------------------------|
| $\tau_{V0}$                                 | $23 \pm 1$                                     | 0 Faded state                                  |
| $\tau_{V1}$                                 | $23 \pm 1$                                     | $50000 \pm 5000$                               |

The requirements specified in ISO 12312-1 shall be measured and calculated from the spectral transmittance values measured in the darkened state ( $\tau_{V1}$ ) after 15 minutes' irradiance with  $(50\,000 \pm 5\,000)$  lx at  $(23 \pm 1)$  °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,  $Q_{\text{red}}$ ,  $Q_{\text{yellow}}$ ,  $Q_{\text{green}}$  and  $Q_{\text{blue}}$ , 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.

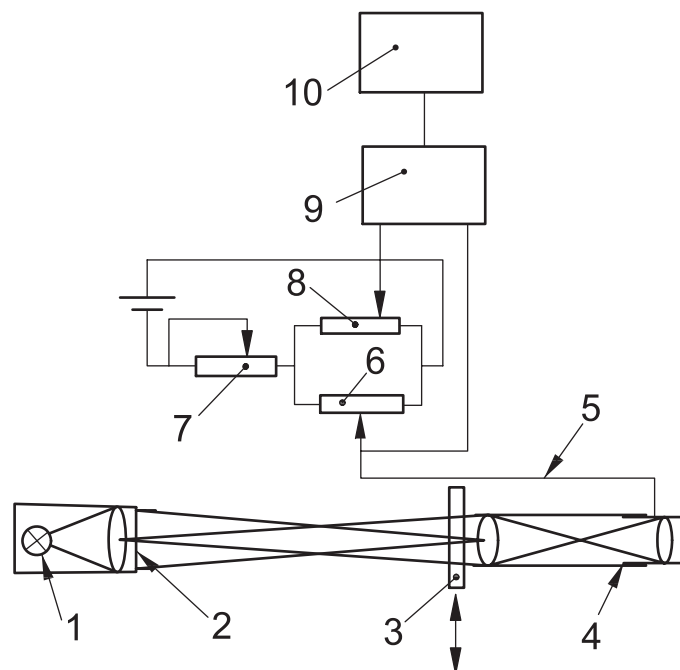
**NOTE** The recommendations given are for reference. Alternative designs that can be demonstrated to produce results that are equivalent to those obtained with the reference method may also be used. For example, a focimeter can be used for the measurement of those optical properties for which equivalent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

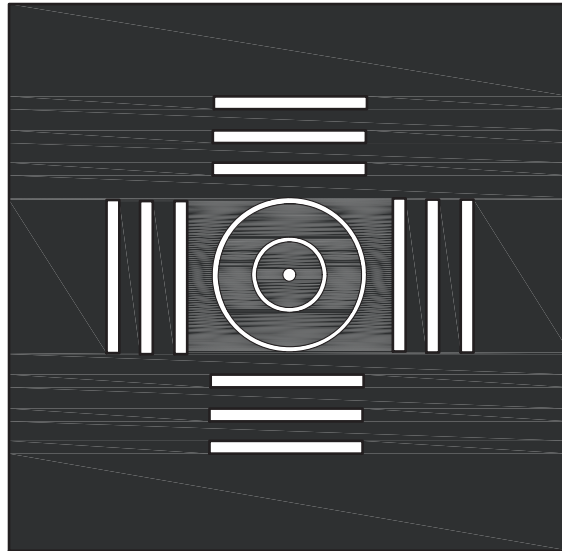


**Figure 7 — Telescope target (dimensions are given in [8.1.2.3](#))**

**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 reticle 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.

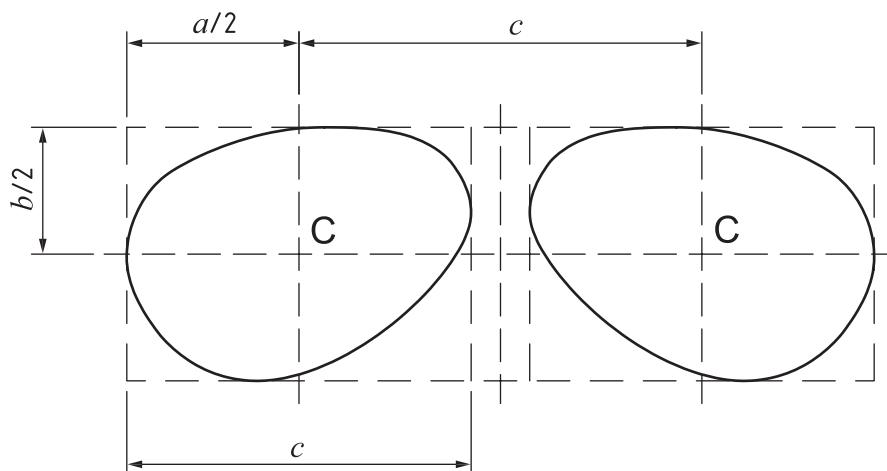
- a) Filter covering one eye:
  - 1) when the as-worn position is specified by the manufacturer, the positioning is as specified;

- 2) when the as-worn position is unknown or not specified by the manufacturer, the positioning is normal to the telescopic axis and the tests are conducted at the boxed centre (see ISO 4007).
- b) Filter covering two eyes:
- 1) when the as-worn position is specified by the manufacturer, the positioning is as specified;
  - 2) when the as-worn position is unknown or not specified by the manufacturer, the positioning is normal to the telescopic axis and the tests are conducted at the reference points (see [Figure 8](#)).

For the positioning of mounted filters the following cases shall apply.

- c) Filters covering one eye:
- 1) when the as-worn position is specified by the manufacturer, the positioning is as specified;
  - 2) when the as-worn position is unknown or not specified by the manufacturer, the positioning is in the as-worn position as specified in ISO 4007.
- d) Filters covering both eyes:
- 1) when the as-worn position is specified by the manufacturer, the positioning is as specified;
  - 2) when the as-worn position is unknown or not specified by the manufacturer; the positioning is in the as-worn position as specified in ISO 4007.

If, in addition to b)2) for mounted and unmounted filters, no interpupillary distance is specified by the manufacturer, a default value of 64 mm for adult's sunglasses and 54 mm for children's sunglasses shall be applied.



#### Key

- C reference points  
 b distance between the tangents to the top and bottom of the filter  
 c the specified interpupillary distance  
 a horizontal boxed ocular size

**Figure 8 — Determination of the reference points for filters**

#### 8.1.4.2 Spherical power and astigmatic refractive power

The target, or the filter, is rotated in order to align the principal meridians of the filter with the bars of the target. The telescope is focused firstly on one set of bars (measurement  $D_1$ ) and then on the perpendicular bars (measurement  $D_2$ ).

The spherical power is the mean  $\frac{D_1 + D_2}{2}$ , the astigmatic power is the absolute difference  $|D_1 - D_2|$ , of the two measurements.

During this process the best focus shall be used across the whole target for each meridian.

#### 8.1.4.3 Prismatic power for unmounted filters covering one eye

The filter shall be placed in front of the telescope in the as-worn position and the deviation of the point of intersection of the lines of the reticule recorded. The prismatic power can be determined taking into account the following and by using linear interpolation:

- a) if the point of intersection is on the outside edge of the large circle, the prismatic power is 0,25 prism dioptre;
- b) if the point of intersection is on the inside edge of the small circle, the prismatic power is 0,12 prism dioptre.

#### 8.1.5 Test report

The measured values (spherical, astigmatic and prismatic power) shall be reported.

### 8.2 Test method for the prism imbalance of complete sunglasses or filters covering both eyes

#### 8.2.1 Principle

This method determines the prism imbalance (relative prism error) in the as-worn position at the two reference points of mounted filters in complete sunglasses, or at the two reference points on the filter if it is of one piece construction.

#### 8.2.2 Apparatus

The arrangement of the reference method is shown in [Figure 9](#). The uncertainty for the determination of the difference in prismatic refractive power is equal to or less than 0,05 prism dioptre. Other methods can be used, e.g. using two parallel laser sources for illumination, provided they are capable of measuring within the required uncertainty.

#### 8.2.3 Test procedure

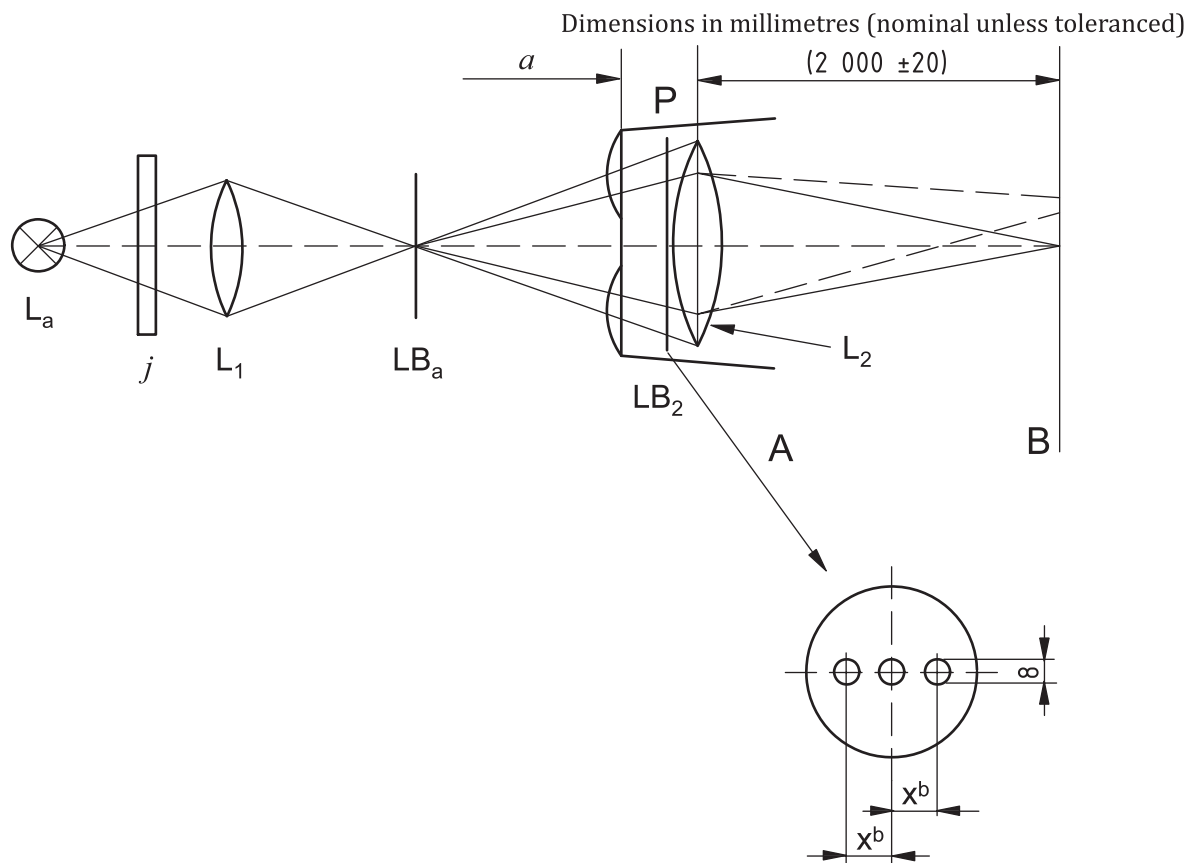
- a) The diaphragm LB<sub>1</sub> is illuminated by the light source L<sub>a</sub>. The position of these is adjusted so that it produces a single image on the screen in plane B when the eye protector (P) is not in position.
- b) The eye protector is placed in front of the lens L<sub>2</sub>, in the as-worn position, on the headform of a size appropriate to the specimen being tested and conforming to the description as indicated in [Annex G](#).

**NOTE** If a justifiable reason exists, e.g. design for fitting a specific ethnicity or population group, the assessment should be carried out on an alternative headform designed to represent the specific target population.

- c) Select the appropriate diaphragm LB<sub>2</sub>. The distance X<sup>b</sup> from the centre of the diaphragm to the left and right circular opening is equal to half of the interpupillary distance. As default value an interpupillary distance of (64,0 ± 0,4) mm for adult sunglasses and (54,0 ± 0,4) mm for children's sunglasses is used. Other values for the interpupillary distance can be chosen if requested by the manufacturer.
- d) Measure the vertical and horizontal distances between the two displaced images arising from the two filter regions of the eye protector.

These distances in centimetres are divided by 2 to give the horizontal and vertical prismatic differences in prism dioptres (centimetres per metre).

If the light paths which correspond to the two eye regions cross in the horizontal direction the prism imbalance is "base in"; if the light paths do not cross, it is "base out".



#### Key

- $L_a$  light source, e.g. small filament lamp, laser with wavelength of  $(600 \pm 70)$  nm
- $j$  interference filter with peak transmittance in the green part of the spectrum (required only if a filament lamp is used as the light source)
- $L_1$  achromatic lens, focal length between 20 mm and 50 mm
- $LB_a$  diaphragm, diameter of aperture 1 mm nominal
- $P$  eye protector
- $LB_2$  diaphragm as shown in detail A
- $L_2$  achromatic lens, 1 000 mm nominal focal length and 75 mm nominal diameter
- $B$  image plane
- $X^b$  half of the interpupillary distance
- $a$  as small as practicable

**Figure 9 — Arrangement of apparatus for measurement of prismatic difference**

#### 8.2.4 Verification and test report

The measured values shall be reported.