INTERNATIONAL STANDARD

ISO 8980-4

Second edition
2006-08-15

Ophthalmic optics — Uncut finished spectacle lenses —

Part 4: Specifications and test methods for anti-reflective coatings

Optique ophtalmique — Verres de lunettes finis non détourés —

Partie 4: Spécifications et méthodes d'essai relatives aux traitements antireflet

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Contents

Page

Foreword

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

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

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

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

ISO 8980-4 was prepared by Technical Committee ISO/TC 172, *Optics and photonics*, Subcommittee SC 7, *Ophthalmic optics and instruments*.

This second edition cancels and replaces the first edition (ISO 8980-4:2000), which has been revised to include non-optical specifications.

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

— *Part 1: Specifications for single-vision and multifocal lenses*

— *Part 2: Specifications for progressive power lenses*

— *Part 3: Transmittance specifications and test methods*

— *Part 4: Specifications and test methods for anti-reflective coatings*

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

Ophthalmic optics — Uncut finished spectacle lenses —

Part 4: Specifications and test methods for anti-reflective coatings

1 Scope

This part of ISO 8980 specifies optical and non optical requirements, including durability, and test methods for anti-reflective coatings on spectacle lenses.

This part of ISO 8980 does not deal with the following topics:

— transmittance and absorptance;

— the colour of the reflected light.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

ISO 8980-1, *Ophthalmic optics — Uncut finished spectacle lenses — Part 1: Specifications for single-vision and multifocal lenses*

ISO 8980-2, *Ophthalmic optics — Uncut finished spectacle lenses — Part 2: Specifications for progressive power lenses*

ISO 8980-3, *Ophthalmic optics — Uncut finished spectacle lenses — Part 3: Transmittance specifications and test methods*

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

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

3 Terms and definitions

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

3.1
durability
⟨of anti-reflective coating⟩ ability to resist deterioration of its reflectance characteristics, over time, in normal use

NOTE 1 The major factors contributing to deterioration of an anti-reflective coating are rubbing, heat, UV radiation and humidity.

NOTE 2 The main failure mechanism affecting the durability of anti-reflective coatings is a loss of adhesion. Therefore, requirements of this part of ISO 8980 are related to anti-reflective coating adhesion.

4 Requirements

4.1 General requirements

Anti-reflective coated lenses shall comply with the general requirements concerning the finished spectacle lens specifications in:

— ISO 8980-1;

— ISO 8980-2;

— ISO 8980-3;

— ISO 14889.

NOTE 1 For further information on the properties of anti-reflective coatings, see informative Annex A.

NOTE 2 The reflectance characteristics of an anti-reflective coating should not significantly change due to deterioration of the coating in normal use.

4.2 Luminous and mean reflectances

The luminous reflectance ρ_V and the mean reflectance ρ_M of an anti-reflective coated lens shall be determined by the method specified in 5.2.

If the manufacturer specifies values for luminous and mean reflectances, the measured values shall not exceed the specified values by more than 20 %.

When determined as described in 5.4, the luminous reflectance ρ_V of any anti-reflective coated lens surface shall be less than 2,5 %.

4.3 Usable diameter of coated area

The usable diameter of the coated area for uncut finished spectacle lenses shall be $\geqslant (d_n - 4)$ mm, where d_n is the nominal diameter of the lens, in millimetres, indicated by the manufacturer.

4.4 Durability

Under the conditions described in the test method given in 5.6, five consecutively tested lenses shall be free of significant loss of adhesion as defined in 5.6.4.

A product meets the durability requirements of this part of ISO 8980 if all five lenses tested satisfy this criterion.

5 Testing

5.1 General

This clause specifies type test methods for anti-reflective coatings on spectacle lenses. At least 24 h shall elapse after coating before any type test is carried out. Lenses shall be stored at a temperature of 20 °C to 26 °C.

5.2 Method of determination of reflectance

5.2.1 Apparatus

Use any dual-beam or single-beam spectrophotometer with an incident angle not larger than 17° and with a measurement accuracy sufficient to give the value of the spectral reflectance at all wavelengths λ between 380 nm and 780 nm with an uncertainty of less than 0,1 % (for example, an anti-reflective coating quoted as having 0,5 % reflectance may be measured as having 0,4 % to 0,6 % reflectance). The wavelength increment of measurement shall not be more than 5 nm. The spectral bandwidth (full width at half maximum, FWHM) shall not exceed 5 nm.

The calibration specimen shall have a surface curvature within 0,50 D of that of the spectacle lens to be tested. The back surface of this specimen shall be designed such that no reflection will interfere with the measurement (e.g. both frosted and painted matt black). The calibration specimen shall be of known refractive index $n(\lambda)$ (uncertainty $\Delta n < 0{,}001$) and have no coating (which could affect its surface reflective properties). The surface shall be cleaned.

5.2.2 Spectacle lens preparation

The surface of the spectacle lens under test shall have a radius of curvature not less than 80 mm. The back surface of the lens shall be designed such that no reflection will interfere with the measurement (e.g. both frosted and painted matt black). The surface shall be cleaned.

5.2.3 Measurement

Insert the calibration specimen and calibrate the spectrophotometer to give a value of 100 %. Then insert the spectacle lens. The spectrophotometer will give the value of the spectacle lens to calibration specimen spectral reflectance ratio $R_T(\lambda)$, expressed as percentage. By using this technique, any error due to surface curvature will be eliminated.

Measure the spectacle lens to calibration specimen spectral reflectance ratio over the range 380 nm to 780 nm, at least every 5 nm.

5.3 Determination of spectral reflectance values

The value of the calibration specimen surface spectral reflectance $R_C(\lambda)$ is calculated theoretically from the refractive index.

$$R_C(\lambda) = \left[\frac{n(\lambda) - 1}{n(\lambda) + 1}\right]^2$$

The value of the spectacle lens surface spectral reflectance is calculated by multiplying the calibration specimen spectral reflectance value by the spectacle lens-to-calibration specimen spectral reflectance ratio:

$$\rho(\lambda) = R_C(\lambda) \times R_T(\lambda)$$

5.4 Determination of luminous reflectance

Calculate the luminous reflectance ρ_V using both the spectral reflectance values $\rho(\lambda)$ and the equation given in ISO 13666.

5.5 Determination of mean reflectance

Calculate the mean reflectance ρ_M using both the spectral reflectance values $\rho(\lambda)$ and the equation given in ISO 13666.

5.6 Determination of durability

5.6.1 Equipment and consumables

5.6.1.1 **Apparatus**, able to produce the environmental cycles as specified in Annex B.

5.6.1.2 **Rubbing tool**, as specified in Annex C.

5.6.1.3 **Inspection facility**, as specified in Annex D.

5.6.2 Test specimens

This test method is applicable to anti-reflective-(AR)coated and hard AR-coated lenses.

Both sides of the lenses shall have a radius of curvature not less than 70 mm.

In order to evaluate a product, five lenses shall be tested.

5.6.3 Test method: Environmental cycling combined with rubbing sequences

5.6.3.1 Clean the lenses with soap and water. Rinse them and dry them with a soft, clean cloth.

5.6.3.2 Check the lenses according to the methods in Annex D. The test lenses shall not have defects such as peeling, scratches, crazing or diffusion.

5.6.3.3 Perform the rubbing sequence described in Annex C on both the convex and the concave sides of all lenses. The rubbing shall be carried out in the centre of each lens surface.

5.6.3.4 Expose the lenses to one environmental sequence of 16 h, as specified in Annex B.

5.6.3.5 Rinse the lenses with water. Gently dry them with a soft, clean cloth, and allow the lenses to cool to room temperature.

5.6.3.6 Perform the rubbing sequence described in Annex C on both convex and concave sides of all lenses, on the same area where the first rubbing sequence was performed.

5.6.3.7 Repeat steps 5.6.3.4 to 5.6.3.6 twice.

NOTE At this point, the lenses will have been subjected to the initial rubbing sequence, followed by three environmental and three rubbing sequences.

5.6.4 Evaluation

Inspect the central 20 mm diameter zone for significant loss of adhesion, on both surfaces of each lens, using the observation conditions described in Annex D.

Significant loss of adhesion is where more than a total of 3 mm^2 of coating has delaminated from either surface. (The delaminated areas on the two surfaces are not summed.) Photographs of lenses passing and failing are provided in Annex E.

6 Information to be made available on request

The values of the luminous reflectance ρ_V and mean reflectance ρ_M and the spectral reflectance curve shall be made available on request for a typical surface with a radius of curvature not less than 80 mm.

7 Reference to this part of ISO 8980

If the manufacturer or supplier claims compliance with this part of ISO 8980, reference shall be made to this International Standard either on the package or in publicly available literature.

Annex A
(informative)

Significance of ρ_V and ρ_M in the description of anti-reflective coated lenses

The luminous reflectance ρ_V represents the ratio of the luminous flux reflected by the lens surface to the incident luminous flux. ρ_V emphasizes the spectral reflectance around the centre of the visible spectrum (around 550 nm) and reduces the importance of the blue and red ends of the spectrum.

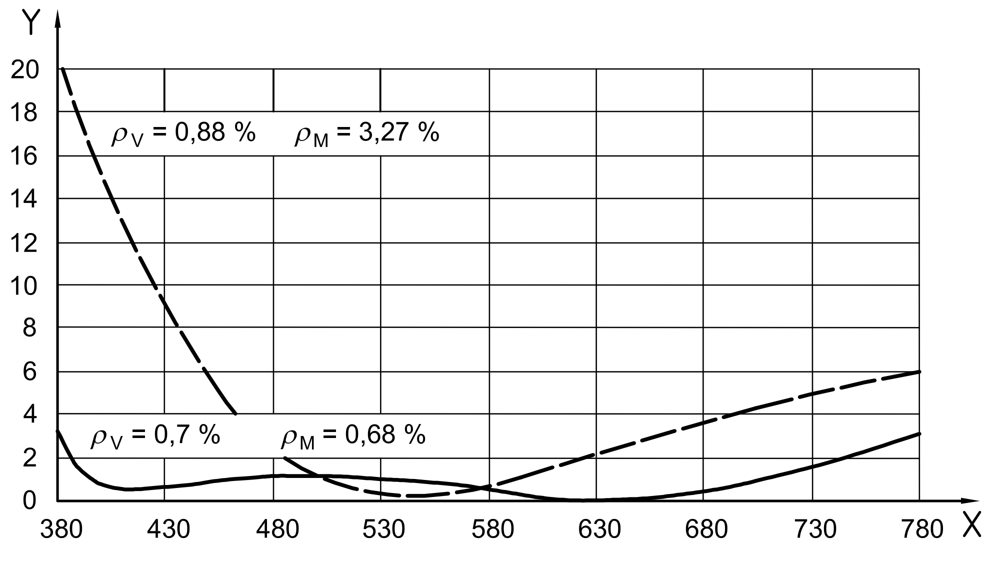
Some types of anti-reflective coating, although having a very low spectral reflectance $\rho(\lambda)$ at the centre of the spectrum, show a marked increase in reflectance at the blue and red ends of the spectrum. Despite having a low luminous reflectance ρ_V, the pronounced coloration of the residual light reflected gives the subjective impression of an overall reflectance higher than suggested by ρ_V.

The mean reflectance ρ_M, which is not weighted by $V(\lambda)$, will, for such types of coating, have a relatively high or poor value. Although an anti-reflective coating having a similar spectral reflectance at the centre of the spectrum and lower (better) reflectance in the blue and red regions will have a similar ρ_V, ρ_M will be lower than for other types of coating.

Hence, the mean reflectance ρ_M gives additional information describing the optical and cosmetic properties of an anti-reflective coating.

NOTE Because types of coating with poor ρ_M show increased reflectance at the ends of the spectrum, glare can result from reflections off the back surface when driving at night. It is expected that additional physiological research will be carried out in this field.

EXAMPLES ρ_V = 0,70 % ρ_M = 0,68 %
ρ_V = 0,88 % ρ_M = 3,27 %



Key

X wavelength, nm

Y reflection, %

Figure A.1

Annex B
(normative)

Environmental sequence

B.1 General considerations

The environmental sequence specified in B.2 to B.5 can be conducted with two types of equipment:

— fluorescent light and condensation (ASTM D 4329-92);

or

— xenon irradiation equipment described in ISO 9022-9, combined with water immersion as described in B.5.

B.2 Conditions for the environmental sequence

For each environmental sequence, the lenses shall be submitted to an exposure of 16 h duration, which consists in cycles based on temperature, light irradiation and humidity exposure. The cycles shall be set to be not less than 30 min and not greater than 8 h.

B.3 Irradiation

The lenses shall be exposed with the convex side facing the radiation source, exposing at least 50 mm in diameter of the centre of the lens. The lenses shall be exposed for at least 50 % of the sequence duration to the UV-visible irradiation specified in Table B.1. The data shall include any radiation reflected by the test chamber interior surfaces, but not infrared radiation emitted from the chamber surfaces.

Additionally, the lower wavelengths being more active, the dose per sequence in the 320 nm to 350 nm region shall be not less than 0,5 MJ/m^2 and not greater than 0,7 MJ/m^2. As a consequence, if the irradiation source emits more than 10 W/m^2 in the 320 nm to 350 nm region, then the UV-visible exposure shall not be continuous and shall be adjusted to a percentage of time defined to meet the specified dose.

Because different sources exhibit different distributions of UVA radiation, both the total UVA radiation and the UVA radiation below 350 nm and above 350 nm shall be controlled, as defined in Table B.1.

Ozone generated during exposure shall be removed from the test chamber.

Table B.1 — Spectral energy distribution of the radiation source

Spectral range		Ultraviolet			Visible		Infrared	
Wavelength band	nm	to 320	320 to 350	350 to 380	380 to 520	520 to 640	640 to 780	780 to 3 000
Irradiance	W/m^2	—	30 to 40 [a]		—	—	—	—
		< 3	10 to 22	14 to 25	< 250	< 210	< 200	< 600

[a] Integrated irradiance between 320 nm and 380 nm.

B.4 Temperature specification

The surface temperature of the lenses shall be maintained below 50 °C during all environmental sequences, and shall reach a minimum of 35 °C during irradiation alone.

B.5 Water exposure

The lenses shall be exposed to water or water vapour for at least 15 % but not more than 50 % of the environmental sequence. If the lenses are exposed to liquid water, the water used shall be deionized (< 2 µs·cm^{-1}), and the water temperature shall be maintained below 30 °C.

NOTE Examples of environmental sequences are given in Annex F.

Annex C
(normative)

Rubbing sequence procedure

C.1 Materials and apparatus

C.1.1 Rubbing tool

The abrasion tool allows the controlled positioning and movement of an eraser covered with micro-fibre cloth against the test surface. The abrasion tool is calibrated to apply a force of (5 ± 1) N.

NOTE A model of an abrasion tool is shown in Annex G.

C.1.2 Eraser

The eraser shall be a uniform rubber formed by extrusion. The formulation shall not contain any ingredient that might leave a residue on the surface under test that would lubricate subsequent strokes during the test procedure. The finished eraser shall have an international rubber hardness degree (IRHD) in accordance with ISO 48 of (75 ± 5) on both ends. The diameter of the eraser shall be from 6,5 mm to 7 mm. It shall be free of any excessive holes, cracks, splits, or foreign particles, which might adversely affect its use.

C.1.3 Micro-fibre cloth

Sufficient quantity of micro-fibre cloth (e.g. a piece of 30 mm × 30 mm size).

NOTE The cloth used is a synthetic micro-fibre cloth as usually supplied by the opticians to their customers for lens cleaning.

This cloth shall be a high density knitted fabric made of ultra fine filaments of polyamide. The fabric shall meet the following specifications:

— minimum density of fibres: 10 000 fibres/cm^2;

— surface density: approximately 165 g/m^2;

— thickness: approximately 0,4 mm.

NOTE An example of suitable cloth is the micro-fibre cloth MX100 by KB Seiren[1)].

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1) Micro-fibre cloth manufactured to the requirements in Annex C may be available from:

FACOL
27, rue d'Iéna
BP 60482
59060 Roubaix cedex 1
France

This information is given for the convenience of users of this International Standard and does not constitute an endorsement by ISO of the product named. Equivalent products may be used if they can be shown to lead to the same results.

C.1.4 Beaker

A beaker with a capacity of 1,5 l.

C.1.5 Deionized water

0,5 l of deionized water.

C.2 Procedure

C.2.1 Preparation of the rub cloth

A new cloth shall be used for each rubbing sequence on each lens.

Before use, the cloth shall be immersed in deionized water for at least 2 min so that its fibres are impregnated.

C.2.2 Lens rubbing sequence

C.2.2.1 When possible, the rubbing sequence given in C.2.2.2 to C.2.2.9 should be performed using a machine instead of doing it manually, as manual testing will result in more dispersed results.

C.2.2.2 Take the cloth out of the water, fold the cloth so that there will be three layers and put it between the rubber and the lens.

C.2.2.3 Position the cloth with its centre at 15 mm from the centre of the lens. Place the tool (C.1.1) with the rubber (C.1.2) mounted on it, on top of the cloth, the rubber being in contact with the cloth, in its centre.

C.2.2.4 Perform 25 cycles of rubbing, applying very precisely the conditions described in C.2.2.4 to C.2.2.9.

C.2.2.5 During the whole rubbing sequence, apply and control precisely the load of (5 ± 1) N (C.1.1) following a path (30 ± 5) mm long and crossing the centre of the lens within ± 3 mm (see Figure C.1);

C.2.2.6 Maintain the tool perpendicular to the surface at all time, within a tolerance of ± 5°.

C.2.2.7 Perform this sequence at a speed of approximately 1 cycle/s.

C.2.2.8 Rotate the test lens by 90° and repeat the rubbing sequence.

C.2.2.9 Each rubbing step shall follow the same track as the first.

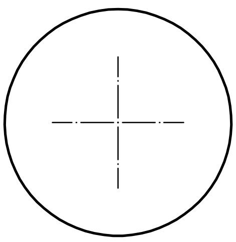


Figure C.1 — Rubbing paths

Annex D
(normative)

Evaluation conditions

D.1 Material and equipment

An adjustable light source, to set the ambient light in the inspection room at 200 lx.

The inspection system shall be as shown in Figure D.1. The inspection source shall be of 400 lm minimum, for example a fluorescent tube of 15 W or a 40 W incandescent clear lamp where the eye of the observer is completely shaded from the direct view of the source.

D.2 Evaluation methodology

Each side of the lens shall be evaluated independently according to the following procedure.

a) rinse the lens with water, and wipe it dry;

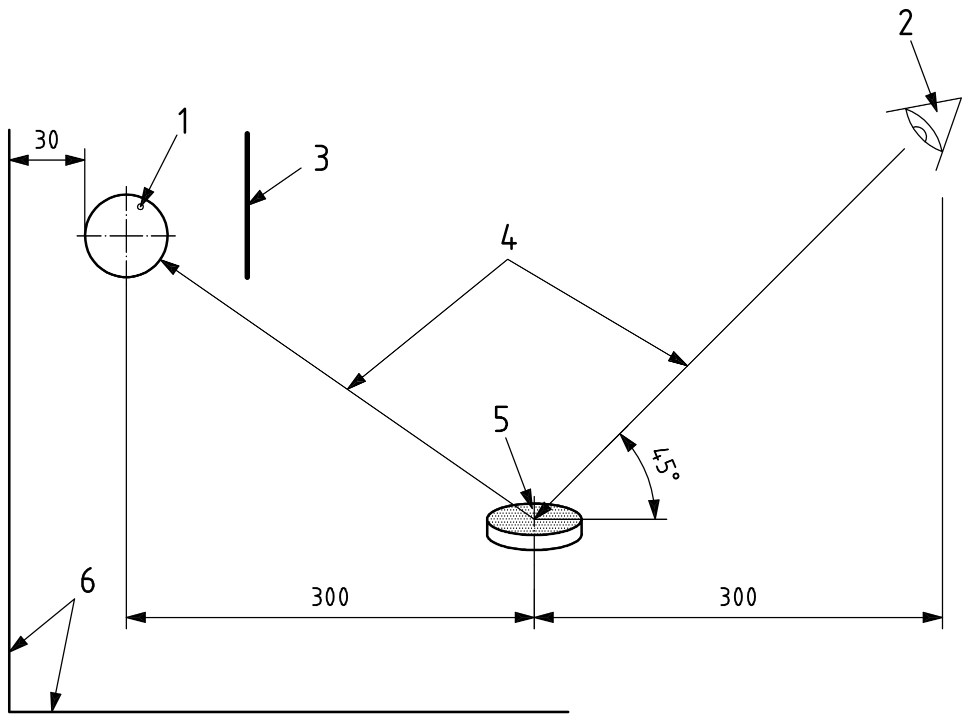
b) set the ambient light source to obtain a lighting of about 200 lx;

c) carry out the lens inspection without the aid of magnifying optics;

d) as shown in Figure D.1, position the lens at an angle approximately 45° with the surface, 300 mm from the light source, against the matt black background;

e) adjust the angle to observe the reflection from the lens surface.

Dimensions in millimetres



Key

1 inspection lamp

2 observer's eye

3 light shield

4 observer's line of sight

5 lens

6 matt black background

NOTE The light shield is adjusted to shield the eye from direct light of the source and to allow the lens to be illuminated by direct light.

Figure D.1 — Recommended configuration for visual evaluation

Annex E
(informative)

Examples of lenses passing and failing the visual evaluation

The photographs given in Figures E.1 and E.2 may be used as help for determining if a lens passes or fails.

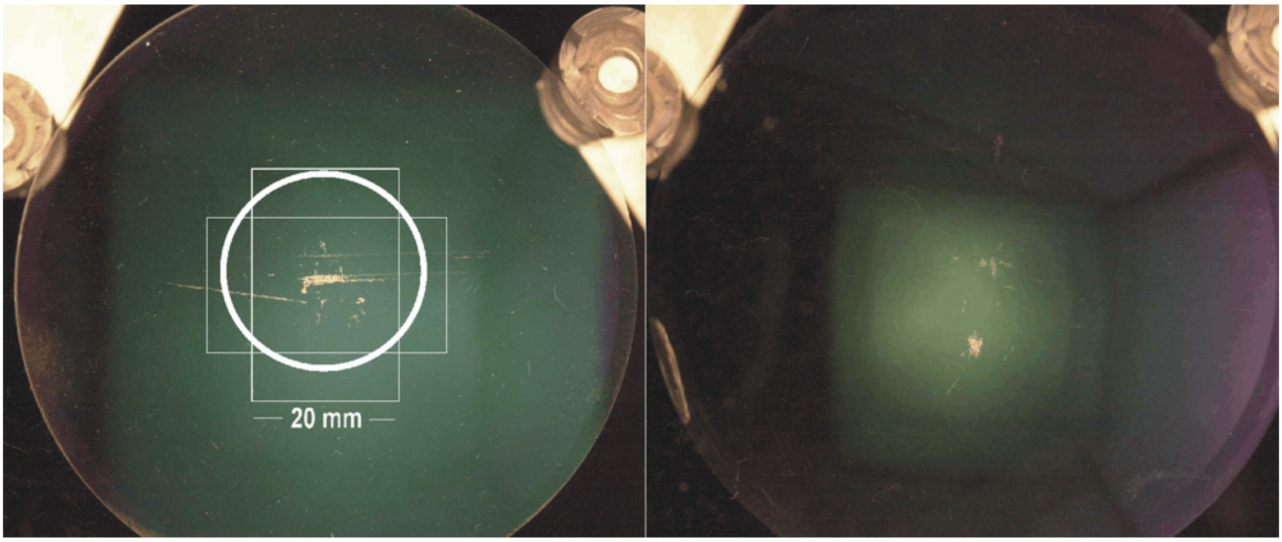


Figure E.1 — Examples of lenses failing

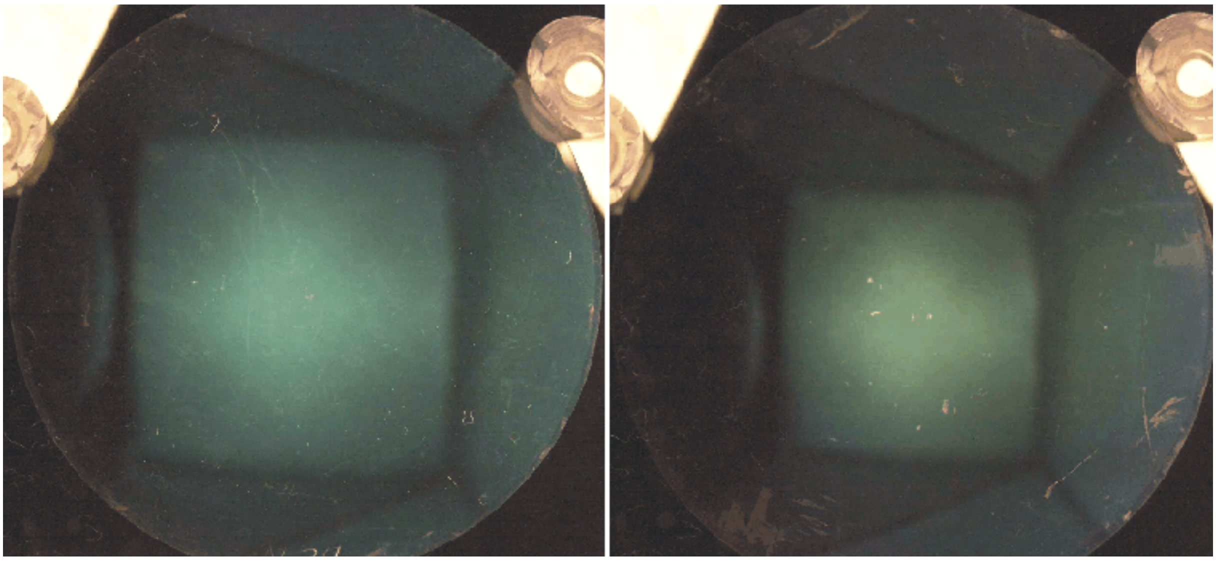


Figure E.2 — Examples of lenses passing

Annex F
(informative)

Examples of environmental sequence

F.1 General

The following three sequences comply with the specifications given in Annex B.

F.2 Sequence on a QUV equipment from QPanel[2)]

The following sequence shall be repeated over a period of 16 h.

— Apply condensation at a temperature setpoint of 45 °C for 4 h.

— Apply UV irradiation with a spectral irradiance of 0,85 W/m^2/nm at 340 nm and at a temperature setpoint of 45 °C for 4 h.

WARNING — The application of condensation shall be the first step to avoid temperature overshoot.

NOTE In order to maintain the temperature of the lenses below 50 °C a proper cooling of their back side is required. This is obtained by mounting the lenses in drilled plates so that their back side is exposed to the air circulation at the back of the plates.

F.3 Cycle on a Suntester from ATLAS[3)]

Apply the following:

---

2) QPanel products may be available from:

QPanel lab products
Express Trading Estate
Stone Hill Road
Farnworth
Bolton BL4 9TP
England

phone (44) 1204 86 16 16
fax (44) 1204 86 16 17
info @ q-panel.co.uk
http://www.q-panel.com

This information is given for the convenience of users of this International Standard and does not constitute an endorsement by ISO of the product named. Equivalent products may be used if they can be shown to lead to the same results.

3) ATLAS Suntester may be available from:

ATLAS Material Testing Technology LLC
4114 North Ravenswood Avenue
Chicago
Illinois 60613
USA www.atlas-mts.com

phone (1) 773 327 4520
fax (1) 773 327 5787

This information is given for the convenience of users of this International Standard and does not constitute an endorsement by ISO of the product named. Equivalent products may be used if they can be shown to lead to the same results.

a) Continuous irradiation for 16 h with a Xenon lamp;

— with a power set to give an irradiance between 30 W/m^2 and 40 W/m^2 in the 320 nm to 380 nm portion of UVA;

— using a UV filter (290 nm cut-off, ATLAS reference 56052371), and an Infrared filter (ATLAS reference 56052388) to limit the temperature elevation on the samples;

b) Immersion in deionized water at ambient temperature for 5 min every 30 min.

NOTE Be aware that with ATLAS Suntester devices the irradiance is controlled in the wavelength range 300 nm to 800 nm. To get a setting of these devices which is consistent with this part of ISO 8980, the Suntester devices have to be calibrated with a UVA sensitive detector. Settings from 350 W/m^2 to 650 W/m^2 have been found necessary to give the proper UVA irradiance.

F.4 Cycle on a QSun from QPanel[2)]

Apply the following:

a) continuous irradiation for 16 h with a xenon lamp;

— with the power set between 30 W/m^2 and 40 W/m^2 in UVA 320 nm to 380 nm region;

— using a “daylight filter”[2)] (290 nm cut-off);

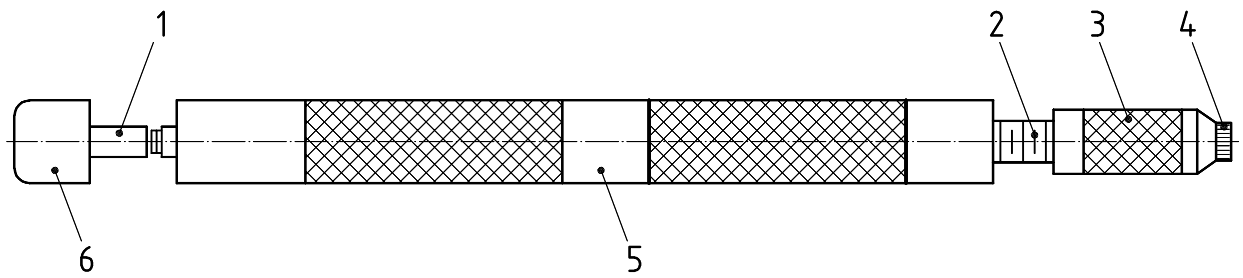
b) spraying with deionized water at ambient temperature for 5 min every 30 min.

Annex G
(informative)

Example of a rubbing tool and components

G.1 Example of rubbing tool[4)]

The plunger, which can move longitudinally within the body of the tool, is fitted at one end with a chuck holding an eraser, while the other end carries a scale or other marking indicating the position of the plunger within the body. The plunger is loaded by a spring to apply a force of (5 ± 1) N when the body is held perpendicular to the specimen surface and the scale or marking is in its required position.



Key

1 indicator rod
2 plunger
3 chuck
4 eraser
5 body
6 cap

Figure G.1 — Model of a rubbing tool

---

4) The rubbing tool and eraser manufactured to the requirements in C.1.1 and in Annex G may be available from:

Summers Optical
321 Morris Road
P.O. Box 162
Fort Washington, PA 19034
USA

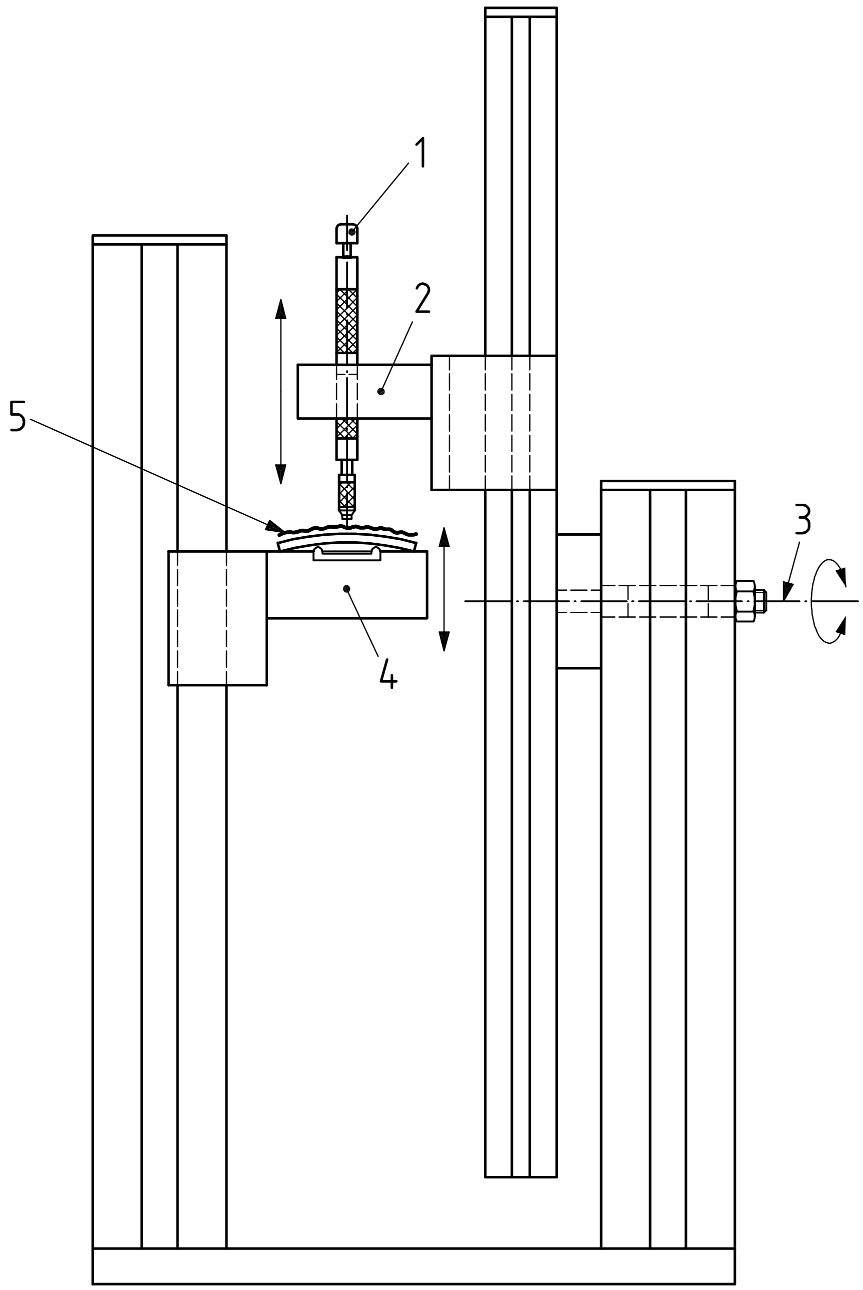
phone (215) 646 1477
fax (215) 646 8931
e-mail sgkcck@aol.com
http://www.emsdiasum.com

This information is given for the convenience of users of the International Standard and does not constitute an endorsement by ISO of this source of supply.

G.2 Example diagram of test mechanization (optional)

Although the test may be performed manually, test mechanization is likely to provide more repeatable results.

The test mechanization should provide a means of securing the lens sample during the procedure, and a means to move the prepared tool perpendicular to the lens surface, within the tolerances specified in C.2.2 while maintaining the applied force specified in C.1.1.



Key

1 rubbing tool

2 holder for tool

3 pivot axis

4 test lens holder

5 microfibre cloth

Figure G.2 — Example of a test mechanism (shown in a configuration for rubbing the convex surface)

Bibliography

[1] ISO 9022-9:1994, *Optics and optical instruments — Environmental test methods — Part 9: Solar radiation*

[2] ASTM D 4329-92, *Standard Practice for Fluorescent UV Exposure of Plastics*

[3] IEC 60068-2-9:1975, *Environmental testing — Part 2: Tests. Guidance for solar radiation testing*

ICS 11.040.70

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