INTERNATIONAL STANDARD

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Optics and optical instruments — Test lenses for calibration of focimeters

Optique et instruments d'optique — Verres étalons pour l'étalonnage des frontofocomètres

Reference number
ISO 9342:1996(E)

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.

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.

International Standard ISO 9342 was prepared by Technical Committee ISO/TC 172, *Optics and optical instruments*, Subcommittee SC 7, *Ophthalmic optics and instruments*.

Annex A of this International Standard is for information only.

International Organization for Standardization
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Optics and optical instruments — Test lenses for calibration of focimeters

1 Scope

This International Standard specifies requirements for test lenses for the calibration of focimeters.

NOTE 1 It is accepted that other test lenses can also be used with powers within the given range, manufactured to the same standard of accuracy and form, but different back vertex powers. However, only lenses with integer nominal powers, as described in Annex A, can be used for the calibration of digitally-rounding focimeters.

2 Normative reference

The following standard contains provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the edition indicated was valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent edition of the standard indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 7944:1984, *Optics and optical instruments — Reference wavelengths.*

3 Definitions

For the purposes of this International Standard, the following definitions apply.

3.1 spherical test lenses: Lenses used for the calibration of the dioptric power measurements by focimeters, in which the power of each lens is expressed as its back vertex power in dioptres (D).

3.2 prismatic test lenses: Lenses used for the calibration of the prismatic deviation measurements by focimeters, in which the prismatic power of each lens is expressed in centimetres deviation per metre distance (cm/m).

NOTE 2 The special name for the unit for expressing prismatic power is the 'prism dioptre' for which the symbol 'Δ' is used.

3.3 cylindrical test lenses: Lenses with cylindrical faces which are used to calibrate the axis marker and axis indicator with respect to the adjustment orientation of the rail.

NOTE 3 These lenses are usually specially designed and marked.

3.4 reference wavelength: Wavelengths specified in ISO 7944.

NOTES

4 For the purposes of this International Standard, the reference wavelengths are either the green mercury line (λ_e = 546,07 nm) or the yellow helium line (λ_d = 587,56 nm).

5 The reference wavelength for which the test lenses are calibrated should be stated.

4 Design requirements and recommendations for test lenses

4.1 General

Test lenses shall be made of homogeneous white crown glass with a refractive index $n_d = 1{,}523 \pm 0{,}002$, or $n_e = 1{,}525 \pm 0{,}002$ selected to be free of bubbles and striae in an area of 4 mm radius surrounding the centre of the free aperture.

NOTE 6 Test lenses should have a protective mount, which is designed so that, when the lens is correctly placed on the lens support, the focimeter is not obstructed.

4.2 Spherical test lenses

For a complete set of spherical test lenses the following set of back vertex powers is recommended:

–25 D, –20 D, –15 D, –10 D, –5 D, +5 D, +10 D, +15 D, +20 D, +25 D

Spherical test lenses should have a free aperture of at least 15 mm.

In order to minimize the influence of spherical aberration, the curvature of the back surface and the centre thickness shall approximately correspond to those of common spectacle lenses. Table 1 gives nominal back surface powers and ranges for centre thickness which will ensure that the lenses are of this form.

4.3 Prismatic test lenses

The optical surfaces of prismatic test lenses shall be plano.

The number of prismatic test lenses that should be used to adjust or to check a focimeter depends on the measuring range of the instrument. If a test lens is used, it shall meet the requirements of this International Standard.

For a complete set, the following set of prismatic deviations is recommended:

2Δ 5Δ 10Δ 15Δ 20Δ

4.4 Cylindrical test lenses

The test lens shall be a rectangular positive plano cylinder of at least 5 D and shall have the dimensions shown in figure 1. The cylinder axis shall be parallel to the longer side of the rectangle and shall be marked by a centreline. One of the longer sides shall be marked as the reference side.

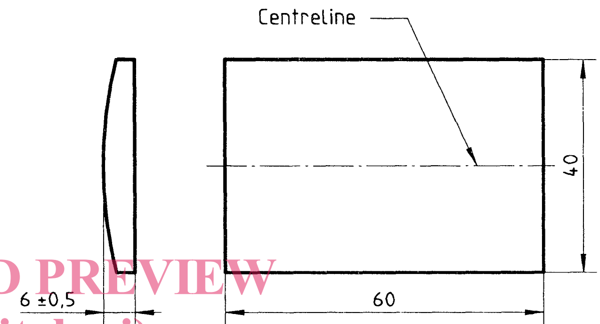

Figure 1 — Cylindrical test lens

Table 1 — Design range for the standard test lenses

Nominal back vertex power, BVP m^{-1} (D)	Nominal back surface power, BSP m^{-1} (D)	Power range for BSP′ m^{-1} (D)	Range for centre thickness*) mm
– 25	– 25	± 1	2-6
– 20	– 20		2-6
– 15	– 15		2-6
– 10	– 12		2-8
– 5	– 9		2-8
+ 5	– 5		3-7
+ 10	– 3		3-7
+ 15	– 1		5-7
+ 20	0		7-9
+ 25	0		9-11

*) The centre thicknesses are required to guarantee stability in the negative power range.

NOTE — Surface power is defined by the equation:

surface power = (refractive index –1)/radius of curvature in metres

5 Tolerances

5.1 Tolerances for spherical test lenses

The permissible tolerances for spherical test lenses shall be as given in table 2.

Table 2 — Tolerances for spherical test lenses

Nominal back vertex power m^{-1} (D)	Tolerance (maximum deviation) m^{-1} (D)
− 25	0,03
− 20	0,02
− 15	0,02
− 10	0,01
− 5	0,01
+ 5	0,01
+ 10	0,02
+ 15	0,02
+ 20	0,03
+ 25	0,03

NOTE 7 In annex A, an example is given for the proper design of test lenses which meet the requirements of tables 1 and 2 for free apertures of up to 9 mm diameter.

5.2 Tolerances for prismatic test lenses

The free aperture of prismatic test lenses shall be at least 15 mm. The tolerances shall not exceed the values given in table 3.

Table 3 — Tolerances for prismatic test lenses

Prismatic deviation cm/m (Δ)	Tolerance cm/m (Δ)
2	± 0,02
5	± 0,03
10	± 0,05
15	± 0,10
20	± 0,15

5.3 Tolerances for cylindrical test lenses

The angular deviation between the cylinder axis and the longer side of the rectangle (see figure 1) shall not exceed 20′ of arc.

The displacement of the centreline from the afocal meridian shall not exceed 0,1 mm.

These tolerances shall not be additive and allow the angular deviation between the cylinder axis and the centreline to be greater than 20′ of arc.

Annex A
(informative)

Manufacture of test lenses for focimeters

A.1 General

Spherical test lenses which meet the tolerances given in 5.1 can be manufactured by observing the following specifications and procedure.

To manufacture test lenses according to this annex, the manufacturer will need a selection of master test surfaces against which the test lens surfaces can be checked using standard precision optical techniques.

A.2 Selection of glass

To manufacture spherical test lenses using this method, precision grade homogeneous optical glass shall be used.

The refractive index should be known to an accuracy of at least $\pm 5 \times 10^{-5}$. Glass should be selected with a refractive index $n_e = 1{,}525 \pm 0{,}001$; $n_d = 1{,}523 \pm 0{,}001$. The dispersion value should be $\nu = 59 \pm 4$. Schott glass K5 is an example of a suitable glass.

A.3 Calculation of the nominal back surface radius of curvature

The nominal radius of the back surface (i.e the surface that is put onto the lens support of the focimeter) is found by using table 1.

For every nominal back vertex power a nominal back surface power is given. The nominal radius of the back surface is found by using the formula given in the note to table 1.

A.4 Selection of the closest standard radius

Using the result of A.3, select from the available master test surfaces the one whose radius is closest to the value calculated according to A.3.

A.5 Calculation of lens thickness and selection of front surface radius

Using the selected value of the back surface radius, the desired back vertex power and a centre thickness which is in the range specified by table 1, the front surface radius is calculated using the standard thick lens paraxial power formula. This radius value is then compared to the available master test surfaces and the master surface radius closest to the desired value is chosen as the front surface radius. Finally the paraxial power formula is again used with the selected values of front and back radius and the known refractive index to calculate the centre lens thickness.

A.6 Production tolerances

Errors may exist in any or all of the four basic lens parameters (front surface radius, back surface radius, thickness and refractive index). If these errors are known, their effect on the total lens power can be directly calculated. However, there is always an uncertainty error associated with any measurement and these errors shall be accounted for. If the production tolerances given in table A.1 are met, the test lenses will meet the precision tolerances of 5.1.

NOTES

8 The radius values of the master test surfaces should be known to sufficient precision to ensure that the error they induce in the total power of the test lens is no more than 0,002 D per surface. This will be achieved if precision is equal to or better than $\pm (r^2) \times 3{,}8 \times 10^{-3}$.

9 These production tolerances assume that individual errors combine in the worst manner to give a maximum total power error. The probable total power error is expected to be $\sqrt{\sum (\text{individual error})^2}$.

Table A.1 — Production tolerances

Nominal back vertex power D	Centre thickness mm	Index of refraction	Fit of lens surface to master test surface	Test lens diameter mm
−25, −20, −15	± 0,2	± 0,000 2	1 interference ring at 20 mm diameter	25 minimum
−10, −5	± 0,1			
+5	± 0,05			
+10 +15 +20 +25	± 0,03			

A.7 Example for a test lens +15,0 D

A.7.1 Calculation of production data

Index of refraction (Schott glass K5) $n_e = 1{,}524\,6$

Calculation of the nominal back surface radius according to table 1 using $D_2 = -1\,D$ $r_2' = \frac{n_e - 1}{D_2} = 524{,}6$ mm

Selection of the closest available master test surface $r_2 = 523{,}30$ mm

Selection of centre thickness within the range of table 1 $d' = 6{,}0$ mm

Calculation of the front surface radius $r_1' = 34{,}847$ mm

Selection of the closest available master test surface $r_1 = 34{,}974$ mm

Calculation of final centre thickness $d = 6{,}37$ mm

A.7.2 Consideration of error summation

Deviation of index of refraction, given by the tightened "tolerance level 1" according to the Schott glass catalogue $\Delta n = \pm 0{,}000\,2$

Deviation of centre thickness according to table A.1 $\Delta d = \pm 0{,}03$ mm

Deviation of front surface radius equivalent to 1 interference ring fit at 20 mm diameter $\Delta = \pm 0{,}005$ mm

Uncertainty of master surface radius $\Delta = \pm 0{,}014$ mm

Maximum uncertainty of front surface radius $\Delta r_1 = \pm 0{,}019$ mm

Deviation of back surface radius equivalent to 1 interference ring fit at 20 mm diameter $\Delta = \pm 1{,}20$ mm

Uncertainty of master surface radius $\Delta = \pm 0{,}16$ mm

Maximum uncertainty of back surface radius $\Delta r_2 = \pm 1{,}36$ mm

Taking into account these deviations of all parameters of a thick lens, the maximum power errror will result to $\Delta D = \pm 0{,}02\,D$

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