INTERNATIONAL STANDARD

# ISO 8598-1

First edition
2014-09-15

# Optics and optical instruments — Focimeters —

## Part 1:
## General purpose instruments

*Optique et instruments d'optique — Frontofocomètres —*

*Partie 1: Instruments pour cas généraux*



Reference number
ISO 8598-1:2014(E)

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# Foreword

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

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

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 172, *Optics and photonics*, Subcommittee SC 7, *Ophthalmic optics and instruments*.

This first edition of ISO 8598-1 cancels and replaces ISO 8598:1996, of which it constitutes a technical revision. It also incorporates the Technical Corrigendum ISO 8598:1996/Cor.1:1998.

ISO 8598 consists of the following parts, under the general title *Optics and optical instruments — Focimeters*:

— *Part 1: General purpose instruments*



# Introduction

General purpose focimeters are intended for measurement of contact lenses, single-vision, multifocal and progressive-power or degressive-power spectacle lenses, both uncut and mounted in spectacle frames, and for the orientation and marking of spectacle lenses.

# Optics and optical instruments — Focimeters —

## Part 1:
## General purpose instruments

## 1 Scope

This part of ISO 8598 specifies requirements and test methods for general purpose focimeters designed for the measurement of vertex powers, cylinder axis, prismatic power and prism base setting within a restricted area at a specified location of a lens. This excludes instruments that can only measure the whole lens at once.

It is applicable to instruments typically intended for use by the ophthalmic community, with the capability to demonstrate conformity of lens products with the International Standards existing for these lenses.

## 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 7944, *Optics and optical instruments — Reference wavelengths*

ISO 8429, *Optics and optical instruments — Ophthalmology — Graduated dial scale*

ISO 9342-1, *Optics and optical instruments — Test lenses for calibration of focimeters — Part 1: Test lenses for focimeters used for measuring spectacle lenses*

## 3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

**3.1**
**adjusting rail**
movable rail or bar used as the reference axis for spectacles during measurement and which is aligned perpendicularly to the optical axis of the focimeter and parallel to the axis direction 0° to 180°

Note 1 to entry: This is also called the lens table or frame rest.

**3.2**
**capability**
ability of a system or process to achieve the required performance

**3.3**
**general purpose focimeter**
instrument that is used to measure vertex powers, cylinder axis and prismatic effects of spectacle and contact lenses, to orientate and mark uncut lenses, and to verify the correct mounting of lenses in spectacle frames

**3.3.1**
**manual focusing focimeter**
instrument that allows the operator to view images formed by rays of light passing through a lens and, by manually focusing and adjusting, to measure the vertex power and identify the principal meridians

Note 1 to entry: For lenses with cylindrical power, the cylinder axis is found using the method provided to locate the principal meridians of the lens in the area defined by the focimeter aperture. Prismatic power is measured separately for this type of focimeter.

Note 2 to entry: There are sub-classes of manual focusing focimeter. One type has an eyepiece whereas the other has a projection screen. With the eyepiece type, the measurement target is focused and viewed through an eyepiece.

**3.3.2**
**automated focimeter**
instrument that measures the vertex power of a lens, in the area defined by the focimeter aperture, in a single measurement without operator adjustment

**3.3.3**
**continuously indicating focimeter**
focimeter with a continuous scale

Note 1 to entry: For the purposes of this part of ISO 8598, this includes both automated instruments when set to 0,06 D or 0,01 D steps and conventional manual focusing instruments.

**3.3.4**
**digitally rounding focimeter**
focimeter which displays measured values rounded to the nearest 0,25 D or 0,12(5) D incremental value

**3.4**
**centration error of the instrument**
residual prismatic error of the instrument with no lens in place

**3.5**
**indication**
⟨of a focimeter⟩ quantitative value provided as the output of the focimeter

**3.6**
**indication error**
difference between the value indicated by the focimeter and the true value of the reference lens

Note 1 to entry: Here the true value of the reference lens, the back vertex power, is calculated using the four known basic lens parameters: radii of curvature of the front and back surface ($r_1$ and $r_2$), the centre thickness ($t$), and the refractive index ($n$) of the reference lens material, using the formulas listed in ISO 9342-1.

Note 2 to entry: When using a measuring instrument, the influence of the uncertainty and indication error of the device should be considered.

**3.7**
**lens support**
mechanical interface of the instrument against which the spectacle lens or the contact lens is placed for measurement

Note 1 to entry: The focimeter measures the vertex power related to the surface placed against the lens support.

**3.8**
**near portion power**
vertex power measured at the near design reference point, as specified by the manufacturer, of a multifocal, progressive-power or degressive-power lens



**3.9**
**non-symmetric error for cylindrical power and cylinder axis**
residual error in the indicated cylindrical power and/or the indicated cylinder axis of a spherocylindrical lens for an automated focimeter after calibration

**3.10**
**non-symmetric prism error of a focimeter**
difference in the prismatic power readings when a plano-prism is measured first with its base setting in one direction and then in the opposite direction, for example, base settings of 180° and 360°, or 90° and 270°

**3.11.1**
**back vertex power**
reciprocal of the paraxial value of the back vertex focal length measured in metres

**3.11.2**
**front vertex power**
reciprocal of the paraxial value of the front vertex focal length measured in metres

Note 1 to entry: Conventionally, the back vertex power, in dioptres, is specified as the "power" of a spectacle lens or a contact lens, although the front vertex power is required for certain purposes, for example in the measurement of some multifocal lenses or progressive-power lenses.

Note 2 to entry: The unit for expressing vertex power is the reciprocal metre ($m^{-1}$). The name for this unit is the "dioptre", for which the symbol is "D".

## 4 Technical requirements for general purpose focimeters

**4.1** The measuring range shall include vertex powers with a range from at least −20 D to +20 D and prismatic powers from 0 Δ to at least 5 Δ.

The instrument shall be capable of measuring the axis direction (see ISO 8429) of cylindrical lenses between 0° and 180°. For prisms, it shall be possible to determine the direction of the base setting between 0° and 360°.

**4.2** For manual focusing focimeters with non-digital display, the dioptric power scale shall have an interval not greater than 0,25 D and shall be clear enough for interpolations to be made to the nearest 0,12 D or less.

For axis directions (see ISO 8429) the scale interval shall not exceed 5° and shall be clear enough for interpolations to be made to the nearest degree.

For prismatic power readings, the scale interval shall not exceed 1 Δ and shall be clear enough for interpolations to be made to the nearest 0,50 Δ.

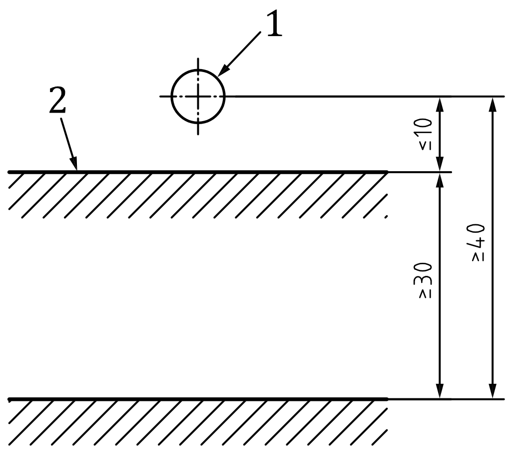
**4.3** For focimeters with digital display in the range from +20 D to −20 D, the minimum step of the display shall be equal to or lower than 0,06 D. The display shall show at least two decimal digits.

For axis directions, the increment of the digital display shall be 1°.

For prismatic power readings, the minimum step of the digital display shall be equal to or lower than 0,06 Δ.

**4.4** The instrument designed to measure spectacle lenses shall be able to measure lenses with a diameter of at least 80 mm and a thickness of at least 20 mm. Translational movements of the lenses on the lens support of not less than 30 mm in a direction perpendicular to the optical axis and to the adjusting rail shall be possible, starting from no more than 10 mm below, in front of, or behind, the optical axis of the instrument, as applicable. The adjusting rail shall also be capable of movement of not less than 30 mm in a direction perpendicular to its length and the optical axis of the instrument. See Figure 1.

Dimensions in millimetres




**Key**

1 lens support

2 adjusting rail

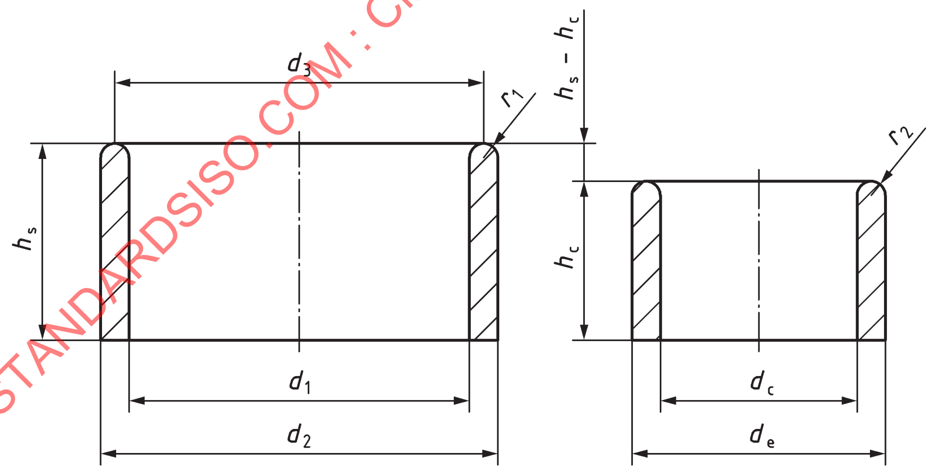
**Figure 1 — Minimum required movement of the adjusting rail**

**4.5** The lens support should be designed so that it does not cause any damage to the lens under test when used in the manner recommended by the manufacturer.

It shall be designed and manufactured so that it will support a lens placed against it, holding the surface that is in contact with it perpendicular to the optical axis of the focimeter.

The lens support shall not adversely affect the accuracy of measurement by introducing sagittal error.

Examples of suitable lens supports are shown in Figure 2.





**Key**

$d_1$, $d_c$ internal diameter of support

$d_2$, $d_e$ external diameter of support

$d_3$ $= (d_1 + d_2)/2$

$h_s$, $h_c$ height of support

$r_1$ $= (d_2 - d_1)/4$

$r_2$ $= (d_e - d_c)/4$

**Figure 2 — Examples of lens supports for spectacle lenses (a) and contact lenses (b)**

For spectacle lenses (a), $d_1$ should be in the range 5 mm to 8 mm while for contact lenses (b), $d_c$ should be 4,5 mm ± 0,5 mm. Because of the increased sagittal depth of steeply-curved contact lenses, the contact lens support is usually smaller in diameter and slightly shorter. The height difference ($h_s - h_c$) should be 0,55 mm ± 0,02 mm.

NOTE The dimensions of the contact lens support are as specified in ISO 18369-3.

The internal diameter ($d_1$, $d_c$) of the lens support for focimeters used for spectacle lens measurement or for contact lens measurement shall be stated by the manufacturer.

**4.6** The pin mark printed by the axis marker shall be small enough to enable the distance between a first and a second mark to be distinguished.

NOTE A diameter of 0,7 mm is recommended.

**4.7** The instrument shall be designed so that it gives stable measured values in a normal environment (i.e. a temperature of 23 °C ± 5 °C, and a relative humidity of less than 85 %).



# 5 Metrological requirements

## 5.1 General

When tested with the reference lenses specified in ISO 9342-1, both manual focusing and automated focimeters shall give indication readings for vertex power and prismatic power over their entire claimed measuring range, and the indication error for the respective true value shall not exceed the limits given in Tables 1 and 2.

## 5.2 Reference wavelength

The instrument shall be manufactured to indicate dioptric powers with reference to the green mercury line $\lambda_e$ = 546,07 nm or the yellow helium line $\lambda_d$ = 587,56 nm, as given in ISO 7944, and the manufacturer shall indicate explicitly which wavelength has been selected.

NOTE If the light source used in the focimeter is not centred on the green mercury line $\lambda_e$ = 546,07 nm or the yellow helium line $\lambda_d$ = 587,56 nm, the user should be able either to set the instrument, or to apply corrections to the indicated values, for lenses made from materials other than the one that was used to calibrate the instrument.

## 5.3 Performance requirement

### 5.3.1 Indication error

When tested in accordance with 6.2.1, the instrument, when fitted with the spectacle lens support, shall not exceed the permissible indication errors given in Tables 1 and 2 when used with the spectacle form reference lenses specified in ISO 9342-1.

The maximum permissible indication errors given in Tables 1 and 2 correspond to the use of the reference lenses specified in ISO 9342-1 with the respective true values.

**Table 1 — Maximum permissible indication error on measured vertex power for general purpose instruments**

Values in dioptres (D)

| Measuring range of vertex power | | Maximum permissible indication error | | |
|---|---|---|---|---|
| | | Instruments with continuous scale | Digitally rounding instruments when set to increments of | |
| | | | 0,25 | 0,12(5)[a] |
| < 0 ≥ −5 | > 0 ≤ +5 | ±0,06 | 0,0 | 0,0 |
| < −5 ≥ −10 | > +5 ≤ +10 | ±0,09 | 0,0 | ±0,12(5) |
| < −10 ≥ −15 | > +10 ≤ +15 | ±0,12 | 0,0 | ±0,12(5) |
| < −15 ≥ −20 | > +15 ≤ +20 | ±0,18 | ±0,25 | ±0,12(5) |
| < −20 | > +20 | ±0,25 | ±0,25 | ±0,25 |

NOTE 1 Calibrating to tighter tolerances (e.g. 10 % of the product tolerance) will improve instrument equivalence and reduce possible differences between two instruments.

NOTE 2 The user should be aware that when a focimeter is set to read in steps of 0,01 D, the readings may not be true to this level of precision.

[a] The meaning of 0,12(5) is that the instruments has been set to 1/8th dioptre steps, displayed as 0,12 D.

**Table 2 — Maximum permissible indication errors on measured prismatic power for general purpose instruments**

Values in prism dioptres (Δ)

| Measuring range of prismatic power | Maximum permissible indication error | | |
|---|---|---|---|
| | Instruments with continuous scale | Digitally rounding instruments when set to increments of | |
| | | 0,25 | 0,12(5)[a] |
| > 0 ≤ 5 | 0,25 | 0 | 0,12(5) |
| > 5 ≤ 10 | 0,25 | 0,25 | 0,25 |
| > 10 ≤ 15 | 0,50 | 0,50 | 0,50 |
| > 15 ≤ 20 | 0,75 | 0,75 | 0,75 |
| > 20 | 1,00 | 1,00 | 1,00 |

NOTE Calibrating to tighter tolerances (e. g. to 10 % of the product tolerance) will improve instrument equivalence and reduce possible differences between two instruments.

[a] The meaning of 0,12(5) is that the instruments has been set to 1/8th dioptre steps, displayed as 0,12 D.

For automated focimeters, when any of the spherical reference lenses is measured after correct centration, it shall indicate less than 0,06 D of astigmatic power.

### 5.3.2 Axis marker for the optical centre of lens

When tested in accordance with 6.3, the position of the axis marker for the optical centre of the lens shall not deviate from the optical axis of the focimeter by more than 0,4 mm.

### 5.3.3 Axis marker alignment

When tested in accordance with 6.4, any misalignment of the orientation of the axis marker shall not exceed the tolerance of ±1° from the 0° to 180° direction of the dial scale for manual focusing instruments or at the 0° (or 180°) value of the indicated axis for automated focimeters.



### 5.3.4 Adjusting rail

When tested in accordance with 6.5, any misalignment of the adjusting rail shall not exceed the tolerance of 1° from the position parallel to the 0° to 180° directions of the dial scale for manual focusing instruments or the 0° (or 180°) value of the indicated axis for automated focimeters.

### 5.3.5 Capability of measuring tinted lenses

When tested in accordance with 6.9, focimeters should be capable of measuring tinted lenses with luminous transmittance $\tau_V \geq 18$ %. The indicated value from measuring the reference lens and neutral reference filter as specified in Clause C.4 shall remain within the maximum permissible indication errors of Table 1. The limited capability of measuring tinted lenses shall be stated if the instrument cannot meet the requirement of measuring tinted lenses with luminous transmittance $\tau_V \geq 18$ %.

NOTE In practice it may be difficult to measure lenses whose colour departs significantly from neutral if the transmittance of the lens at the operating wavelength of the focimeter is less than 18 %.

### 5.3.6 Non-symmetric errors for automated focimeters

#### 5.3.6.1 General

The cylindrical power, cylinder axis and prism error requirements are for automated focimeters that measure sphere, cylinder, cylinder axis and prism simultaneously.

#### 5.3.6.2 Non-symmetric error for cylindrical power

When tested in accordance with 6.6.2, the non-symmetric error for the indicated power readings of the spherocylindrical-power reference lens specified in Clause C.3 shall not exceed 0,06 D sph/0,09 D cyl.

#### 5.3.6.3 Non-symmetric error for cylinder axis

When tested in accordance with 6.6.3, the non-symmetric error for the cylinder axis from each reading of the spherocylindrical-power reference lens specified in Clause C.3 for each orientation shall not exceed ±1°.

#### 5.3.6.4 Non-symmetric prism error

When tested in accordance with 6.6.4, the non-symmetric error for prismatic power for an automated focimeter shall not exceed 0,06 Δ. At the same time, the indicated values for the spherical and cylindrical powers shall not exceed ± 0,06 D.

### 5.3.7 Repeatability for the indication reading of automated focimeters

When tested in accordance with 6.7, the repeatability for indication readings for an automated focimeter shall not exceed 0,06 D within the spherical power range −10 D to +10 D, and shall not exceed 0,12 D within the measuring range over ±10 D.

### 5.3.8 Centration error for manual focusing focimeters

When tested in accordance with 6.8, the residual prismatic error of the focimeter with no lens in place shall not exceed 0,1 Δ.

### 5.3.9 Astigmatic axis repeatability for low-powered cylindrical lenses with manual focimeters

When tested in accordance with 6.10, the standard deviation of the axis readings for a 0,25 D cylindrical lens shall be less than 4°.

# 6 Test procedures

## 6.1 General

The reference lenses described in ISO 9342-1 shall be used to verify that the requirements of 5.1 to 5.3 are met.

The initial calibration of the focimeter and the metrological verification shall be carried out using all of those reference lenses in the reference lens set specified in ISO 9342-1 that are within the measuring range of the instrument.

Manual focusing focimeters should, before use, be set up according to 6.11 and the target focused according to 6.12.

## 6.2 Checking the indication errors

### 6.2.1 Checking the indication errors for vertex power

The spherical reference lenses shall be used to check whether the vertex powers measured by the focimeter meet the permissible indication errors shown in Table 1.

Ensure that the lens support used is the correct one for the reference lens set selected according to 6.1.

Place each individual reference lens with its back surface against the lens support, and centre it on the optical axis of the focimeter.

Measure and record the vertex power.

It is recommended that three independent readings be taken for each reference lens and that the mean value be calculated and taken as the actual measured value of the lens.

NOTE The term “independent reading” means that the reference lens is removed from the support and replaced again between each reading.

### 6.2.2 Checking the indication errors for prismatic power

The prismatic reference lenses shall be used to check whether the prismatic powers measured by the focimeter meet the permissible indication errors shown in Table 2.

For prismatic power measurement, it is recommended that for each of the reference prisms, an independent reading be taken corresponding to each of the 180° and 360° base setting directions. Take the larger reading of the two measured values at 180° and 360° directions as the actual measured value of the reference lens in order to calculate the indication errors.

## 6.3 Checking the axis marker for the optical centre of lens

A spherical reference lens of at least +15 D shall be used to check whether the axis marker for the optical centre of lens meets the requirement in 5.3.3.

Centre the lens so that the indicated prism power is zero, and then mark it with the axis marker. Rotate the reference lens through approximately 180° and re-centre to zero indicated prism power. Re-mark the lens. Half the distance between the centres of the central marks from the first and second measurements is the distance between the position of the axis marker for the optical centre of the lens and the optical axis of the focimeter.



### 6.4 Checking the alignment of the axis marker

The 5 D plano-cylindrical reference lens as specified by ISO 9342-1 shall be used to check whether the alignment of the axis marker meets the requirement in 5.3.2. The axis marker shall be checked using the horizontal centreline on the reference lens.

For manual focusing focimeters, place the 5 D plano-cylindrical reference lens on the lens support with its reference side roughly parallel to the 0° to 180° direction of the dial scale. Mark the lens after focusing and positioning the lens so that a sharp image line formed by the cylinder axis of the reference lens is coincident with the 0° to 180° direction of the dial scale.

For automated focimeters, set the instrument to read in positive transposition, and place the 5 D plano-cylindrical reference lens on the lens support with its reference side roughly parallel to the 0° to 180° direction. Mark the lens after correctly positioning the lens so that the indication of the axis value becomes 0° (or 180°).

The angular deviation between the marked dotted line and the horizontal centreline on the 5 D plano-cylindrical reference lens is the misalignment of the orientation of the axis marker.

### 6.5 Checking the adjusting rail

For manual focusing focimeters, place the 5 D plano-cylindrical reference lens on the lens support with its reference side in contact with the adjusting rail. After focusing to the non-zero principal meridian, move the plano-cylindrical reference lens together with the adjusting rail so that a sharp horizontal line of the test target runs through the centre of the dial scale.

The angular deviation of this line from the 0° to 180° direction of the dial scale (which represents the angular error between the adjusting rail and the dial scale) is the misalignment of the adjusting rail.

For automated focimeters, set the instrument to read in positive transposition and place the 5 D plano-cylindrical reference lens on the lens support with its reference side in contact with the adjusting rail.

After moving the lens together with the adjusting rail so that the indication of the vertical prism value becomes 0 Δ, the deviation of the indicated cylinder axis from 0° (or 180°) is the misalignment of the adjusting rail.

### 6.6 Checking the non-symmetric error for automated focimeters

#### 6.6.1 General

This procedure shall be used only for automated focimeters.

The spherocylindrical-power reference lens specified in Clause C.3 shall be used to check whether the non-symmetric error for cylindrical power reading and cylinder axis meet the requirements of 5.3.6 according to following procedure.

#### 6.6.2 Checking the non-symmetric error for cylindrical power

Place the spherocylindrical-power reference lens on the lens support with one of its sides against the adjusting rail, and then centre it in order to obtain the spherical-cylindrical power and axis readings. Rotate the lens through 45° so that an adjacent side is on the adjusting rail and measure the spherical-cylindrical power and new axis direction. Repeat until eight spherocylindrical power and axis readings are obtained, one for each side of the lens.

The absolute value of the difference between the maximum and minimum readings for the cylindrical power among the eight cylindrical power measurements is the non-symmetric error for cylindrical power.

### 6.6.3 Checking the non-symmetric error for cylinder axis

Using the eight axis values found in 6.6.2, calculate the difference between the value found for each side and the value found for the side 45° clockwise from it. Each of the eight differences thus found shall not differ from 45° by more than 1°.

### 6.6.4 Checking the non-symmetric prism error

Using the prism reference lens of 2 Δ specified in ISO 9342-1, obtain a pair of prism power readings for base settings of 180° and 360°.

Repeat for base settings of 90° and 270°.

The difference between the two readings of each pair is the non-symmetric prism error.

## 6.7 Checking the repeatability of vertex power measurement for automated focimeters

Using the negative and positive spherical reference lenses of nominal power 5 D and 15 D, take three readings for each lens with the instrument set at the 0,06 (or smaller) indication step. Additional measurements may also be made on reference lenses of other powers. The difference between the maximum and minimum indication reading of each lens is the repeatability of vertex power measurement.

## 6.8 Checking for the centration error

This procedure shall be used only for manual focusing focimeters. Use the procedure given in 6.12 with no lens or prism in place.

The deviation between the centre of the eye-piece or projection screen reticule and the target shall not be more than 0,1 Δ.

## 6.9 Checking the capability of focimeters to measure tinted lenses

Use the reference filter specified in Clause C.4.

First, measure a spherical reference lens as specified in ISO 9342-1 and record the vertex power reading with no filter in place. Keeping the powered reference lens against the lens support, place the filter in the measurement beam with the spherical reference lens still in place against the lens support and record the vertex power reading. The measured values should meet the requirements specified in 5.3.5.

During the second measurement, check the following:

a) Is it easy to centre the lens?

b) Is the indication reading provided stable or fluctuating?

c) Are both readings within the maximum permissible indication error specified in Table 1?

## 6.10 Checking the astigmatic axis repeatability for low-powered cylinder lens

This procedure shall be used only for manual focimeters.

Place a lens of positive or negative cylindrical power 0,00 D/±0,25 D on the spectacle lens support at any axis. It is recommended that the lens be an ophthalmic trial case lens but a spectacle lens complying with ISO 8980-1 may also be suitable provided the cylindrical power is 0,25 D ± 0,06 D.

Position the lens so that the image is in the centre of the field of view, and measure and record the cylinder axis. To obtain subsequent independent readings, defocus the instrument with the power adjustment control and rotate the eyepiece reticule and, if appropriate, the orientation of the target, without touching the test lens. Make at least a further nine independent readings and calculate the standard deviation.

NOTE This test should be performed by an experienced focimeter user who has good visual acuity.

## 6.11 Special procedures for eyepiece focimeters

### 6.11.1 Setting-up procedure

Set the instrument to read 0,00 D.

Unscrew the eyepiece out fully. Look through the eyepiece and slowly screw the eyepiece in until the image of the target just comes into focus.

NOTE If the eyepiece is screwed too far in for any particular operator this will induce ocular accommodation and increase the measurement error.

### 6.11.2 Checking for the absence of parallax

After focusing the target as described in 6.11.1, check for the absence of parallax. The observer shall move his/her eye from side to side above the eyepiece. During this movement, the image of the target shall not move noticeably with respect to the cross hairs.

## 6.12 Criterion for image focusing in manual focusing focimeters

Generally, the target designs in a manual focusing focimeter are in one of four forms: a circle of dots, cross lines, a combination of cross lines and a circle of dots, or a combination of cross lines and a circle of dots with several rows of dots in the middle. Obtaining indication values of dioptric power requires focusing of the target by the operator. Due to the different forms of target in manual focusing focimeters, a common criterion for image focusing is required to avoid the deviation of indication readings caused by differences in image focusing criteria between operators.

NOTE 1 If the target is in the form of a circle of dots, or cross lines, or a combination of a circle of dots and cross lines, the best focus plane should be chosen as the best overall focus.

NOTE 2 Contact lenses have very steep curvature giving spherical aberration. This may affect the results when measuring the power. If the target is in the form of a circle of dots, the best focus plane should be chosen as the best overall focus. If the target is in the form of cross lines, the best overall focus should be selected for the central area of apparent diameter about 20 mm.

# 7 Marking

## 7.1 Reference to ISO 8598-1

If the manufacturer or supplier claims compliance with this part of ISO 8598, reference shall be made to ISO 8598-1 either on the package or in available literature.

## 7.2 General information to be supplied by the manufacturer

The packaging shall be marked, but not be limited to the following information:

a) name and address of the manufacture and/or trade name;

b) serial number;

c) any warning and/or precautions to take.

### 7.3 Additional information to be supplied by the manufacturer

The information shall include, but not be limited to, the following:

a) the reference wavelength used for calibration;

b) how to change the Abbe number setting, if needed;

c) the measurement range;

d) the optical system principle used, i.e. either Focus on Axis (FOA) or Infinite on Axis (IOA)[1)];

e) the limited capability of measuring tinted lenses should the instrument not meet the requirement of measuring lenses with luminous transmittance $\tau_V \geq 18$ %;

f) instructions for maintenance including calibration check.



1) For further information, see ISO 13666 and ISO/TR 28980.

# Annex A
(informative)

# Use of correction values when measuring spectacle lenses

## A.1 General

A focimeter, like all measuring devices, has tolerances around its measurements.

Systematic accuracy errors can be minimized through the use of a set of correction values as recommended in Annex A.

## A.2 Terms and definitions

### A.2.1

**correction**

compensation for an estimated systematic effect

NOTE 1 See JCGM 200:2008, 2.17 for an explanation of "systematic measurement error".

NOTE 2 The compensation can take different forms, such as a constant value to be added or a multiplication factor, or can be deduced from a table or graph.

## A.3 Preparatory to a measurement

### A.3.1 General

The reference lenses specified in ISO 9342-1 may be used to determine correction values as specified in this annex. This method can be applied to all types of instruments measuring spectacle lenses.

### A.3.2 Choice of reference lenses and lens support

When calibrating a focimeter to generate the data needed to create a set of correction values, the reference lenses used should be of the form of the ophthalmic lenses being measured and for which the correction values will be used. In addition, the lens support used should be that which will be used when the chosen type of ophthalmic lenses are measured.

### A.3.3 Measurement condition

**A.3.3.1** The test conditions should be a room temperature of 23 °C ± 5 °C, and relative humidity < 85 % RH.

**A.3.3.2** Before calibration, both the reference lenses and the focimeter(s) under test should be maintained in an environment that meets the requirement in A.3.3.1 for at least 2 h.

**A.3.3.3** The front and back surfaces of reference lenses should be kept clean. Care should be taken to avoid damage to a lens when cleaning it.

NOTE Reference lenses that are assembled within a mount should never be disassembled or adjusted.

### A.3.4 Special procedure for manual focusing focimeters

#### A.3.4.1 Checking for the absence of parallax for eyepiece focimeters

Optical parallax from operators should be eliminated before measurement. The procedure as specified in 6.11.2 shall be used to check the absence of parallax.

#### A.3.4.2 Criterion for image focusing

The procedure specified in 6.12 shall be used to obtain the plane of best image-focus for a manual focusing focimeter.

## A.4 Calculation of the correction value

### A.4.1 Indication error of a focimeter

The indication error is defined as the difference between the actual measured value of a reference lens by the instrument and the true value of the reference lens. The true value for each spherical reference lens is to be found in a certificate issued by a qualified laboratory.

The indication error $d_D$ is given by the following equation:

$$d_D = D_m - D_n \tag{A.1}$$

where

$D_m$ is the indication reading of a reference lens by a focimeter;

$D_n$ is the true value of the reference lens.

NOTE 1 The true value of a reference lens is defined as a calculated value, which is based on actual measurements of the individual design parameters of the reference lens, such as refractive index, radius of curvature of lens surfaces and central thickness. These are measured using procedures and/or equipment traceable to certificates issued by an authorized metrology laboratory. The meaning of the true value of a reference lens is not the same as the nominal value of the lens.

NOTE 2 National legislation may define different requirements for authorizing certificates.

### A.4.2 Correction value for calibrated focimeter

Value defined as the modification applied to a measured value obtained from calibration, to compensate for a systematic effect.

The correction value $d_C$ is expressed by the following equation:

$$d_C = - d_D \tag{A.2}$$

where $d_D$ is the indication error of the focimeter.



### A.4.3 Calculation example

#### A.4.3.1 Measuring a positive reference lens

Take a reference lens with a nominal value of +5,00 D. Suppose the three independent indication readings given by the focimeter to be calibrated are +5,06 D, +5,08 D and +5,04 D respectively. Then the actual measured value $D_m$ (the mean value of indication readings) can be calculated as:

$$D_{m5} = (5{,}06 + 5{,}08 + 5{,}04)/3 = +5{,}06\ (D)$$

The authority certificate gives the true value for each spherical reference lens. Here the symbol $D_{n5}$ is used to represent the true value of the +5 D lens. Suppose the true value for this lens is +4,98 D, and then the indication error $d_{D5}$ of this focimeter being calibrated by the reference lens with a nominal value of +5,00 D for the power range around +5 D can be calculated as follows:

$$d_{D5} = D_{m5} - D_{n5} = 5{,}06 - 4{,}98 = 0{,}08\ (D)$$

Then the correction value $d_{C5}$ for this calibrated focimeter around +5 D can be calculated as:

$$d_{C5} = -d_{D5} = -0{,}08\ (D)$$

Thus, the indication error of the calibrated focimeter around +5 D is 0,08 D and the correction value is −0,08 D.

Similarly, indication errors for other powers of positive reference lenses and the correction values for the calibrated focimeter can be calculated and listed as in Table A.1 or represented in a graph.

#### A.4.3.2 Measuring a negative reference lens

Take a reference lens with a nominal value of −10,00 D. Suppose the three independent indication readings given by the calibrated focimeter are −10,07 D, −10,04 D and −10,08 D respectively. Then the actual measured value $D_m$ (the mean value of indication readings) can be calculated as:

$$D_{m\text{-}10} = (-10{,}07 - 10{,}04 - 10{,}08)/3 = -10{,}06\ (D)$$

The authority certificate gives the true value for each spherical reference lens. Here the symbol $D_{n-10}$ is used to represent the true value of the −10 D lens. Suppose the true value for this lens is −9,96 D, then the indication error $d_{D-10}$ of this focimeter being calibrated by the reference lens with a nominal value of −10,00 D for the power range around −10 D can be calculated as follows:

$$d_{D\text{-}10} = D_{m\text{-}10} - D_{n\text{-}10} = -10{,}06 - (-9{,}96) = -0{,}10\ (D)$$

Then the correction value $d_{C-10}$ for this focimeter around −10 D can be calculated as:

$$d_{C\text{-}10} = -d_{D\text{-}10} = +0{,}10\ (D)$$

Thus, the indication error of the calibrated focimeter around −10 D is −0,10 D and the correction value is +0,10 D.

Similarly, indication errors for other powers of negative reference lenses and the correction values for the calibrated focimeter can be calculated and listed as in Table A.1 or represented in a graph.

**Table A.1 — List of correction values for a calibrated focimeter**

Values in dioptres (D)

| Values of reference lenses | | Indication readings by focimeter | | | Mean value | Correction value |
|---|---|---|---|---|---|---|
| Nominal | Certified | 1 | 2 | 3 | | |
| +25,00 | | | | | | |
| +20,00 | | | | | | |
| +15,00 | | | | | | |
| +10,00 | | | | | | |
| +5,00 | | | | | | |
| +2,50 | | | | | | |
| 0 | | | | | | |
| −2,50 | | | | | | |
| −5,00 | | | | | | |
| −10,00 | | | | | | |
| −15,00 | | | | | | |
| −20,00 | | | | | | |
| −25,00 | | | | | | |

## A.5 Using correction values while measuring lens samples

### A.5.1 General

Table A.1, when completed, will give a series of correction values for each of the reference lenses with nominal indication readings from −25,00 D to +25,00 D respectively. To apply the correction values, as per those found in Table A.1, to the indicated values given by the focimeter being used, add the correction values to the indicated values.

### A.5.2 Examples of using correction values

#### A.5.2.1 Correction for a positive lens

A spectacle lens with a nominal value of +5,00 D is measured. The mean value from three indication readings by the focimeter is 5,14 D. The tolerance around +5,00 D for the back vertex power of lenses given by ISO 8980-1 is ±0,12 D, so it does not pass. The correction value given by the calibration or a metrology certificate, for a lens of power around +5,00 D for this calibrated focimeter is −0,08 D. Then the actual lens power is obtained from the algebraic sum of the two numbers as follows:

5,14 D mean value of indication readings + (−0,08 D correction value) = 5,06 D

The actual lens power for this spectacle lens is +5,06 D.

#### A.5.2.2 Correction for a negative lens

A spectacle lens with a nominal value of −10,00 D is measured. The mean value from three indication readings by the focimeter is −10,21 D. The tolerance for the vertex power of lenses given by ISO 8980-1 is ±0,18 D, so it does not pass. The correction value given by the calibration or the metrology certificate, for a lens of power around −10,00 D for this calibrated focimeter is +0,10 D. Then the actual lens power is obtained from the algebraic sum of the two numbers as follows:

−10,21 D mean value of indication readings + (0,10 D correction value) = −10,11 D

The actual lens power for this spectacle lens is −10,11 D.

## A.6 Verification period

To ensure the measured value of the vertex power of a spectacle lens is reliable, the calibration of a focimeter in use should also be verified periodically.

# Annex B
(informative)

# Example for evaluation of uncertainty of measurement for automated focimeters for general use

## B.1 General

The “uncertainty of measurement” establishes general rules for evaluating and expressing uncertainty in measurement that can be followed at various levels of accuracy and in many fields from the shop floor to fundamental research.

The word “uncertainty” means doubt, and thus in its broadest sense “uncertainty of measurement” means doubt about the validity of the result of a measurement. It is a parameter, associated with the result of a measurement that characterizes the dispersion of the values that could reasonably be attributed to the measurement.

Often in practice, especially in the domain of legal metrology, a device is tested by comparison with a measurement standard and the uncertainties associated with the standard and the comparison procedure are negligible relative to the required accuracy of the test. An example is the use of a set of well-calibrated mass to test the accuracy of a commercial scale.

Automated focimeters, as an important commercial test device for spectacle lenses, are in the same situation under a legal metrological control. They are calibrated with the reference lenses conforming to ISO 9342-1.

Annex B gives an explanation of the evaluation of uncertainty in measurement of back vertex power for a calibrated automated focimeter for general use.

The procedure of evaluation and analysis includes the judgment method for Type A and Type B, the calculation of combined standard uncertainty and of expanded uncertainty, and examples of applying the expanded uncertainty.

## B.2 Terms and definitions

### B.2.1

**standard uncertainty**

uncertainty of the result of a measurement expressed as a standard deviation

### B.2.2

**Type A evaluation (of uncertainty)**

method of evaluation of uncertainty by the statistical analysis of a series of observations

### B.2.3

**Type B evaluation (of uncertainty)**

method of evaluation of uncertainty by means other than statistical analysis of a series of observations



**B.2.4**

**combined standard uncertainty**

$u_c$

standard uncertainty of the result of a measurement when that result is obtained from the values of a number of other quantities, equal to the positive square root of a sum of terms, the terms being the variances or covariance of these other quantities weighted according to how the measurement result varies with changes in these quantities

**B.2.5**

**expanded uncertainty**

$U$

quantity defining an interval about the result of a measurement that may be expected to encompass a large fraction of distribution of values that could reasonably be attributed to the measured value

NOTE 1 To meet the needs of some industrial and commercial applications, as well as requirements in the areas of health and safety, an expanded uncertainty $U$ is obtained by multiplying the combined standard uncertainty $u_c$ by a coverage factor $k$.

NOTE 2 The fraction may be viewed as the coverage probability or level of confidence of the interval.

**B.2.6**

**coverage factor**

$k$

numerical factor used as a multiplier of the combined standard uncertainty in order to obtain an expanded uncertainty.

NOTE The value of the coverage factor $k$ is chosen on the basis of the level of confidence required of the interval $y - U$ to $y + U$. In general, $k$ will be in the range 2 to 3. In practice, one can assume that taking $k = 2$ produces an interval having a level of confidence of approximately 95 %, and that taking $k = 3$ produces an interval having a level of confidence of approximately 99 %.

## B.3 Evaluation of uncertainty of measurement

### B.3.1 General

After calibration, the metrology certificate may offer a table or graph of correction values for indication readings of back vertex power for the calibrated focimeter.

The evaluation procedure for the uncertainty of the given correction values is as described in B.3.2 to B.3.5.

### B.3.2 Evaluating standard uncertainty

#### B.3.2.1 Model the measurement

In most cases a measured value $d$ is determined from $n$ other quantities through a functional relationship. So, it is necessary to establish a mathematical model to show the relationship between the measurement method and the measuring procedures.



The correction value for indication readings of back vertex power is determined by

$$c = \Phi - d \quad \text{(B.1)}$$

where

$c$ is the correction value for indication readings of back vertex power;

$\Phi$ is the true value of the power of the reference lens;

$d$ is the indication reading given by the focimeter being used.

Knowing that the standard uncertainty for each component is:

$$u_1 = u(\Phi) \quad \text{(B.2)}$$

$$u_2 = u(d) \quad \text{(B.3)}$$

Because $u_1$ and $u_2$ are independent of each other,

$$u_c = (u_1{}^2 + u_2{}^2)^{1/2} \quad \text{(B.4)}$$

### B.3.2.2 Standard uncertainty for each component

#### B.3.2.2.1 General

Uncertainty of measurement comprises, in general, many components. Assuming a statistical distribution for the results of series of measurements, the possible range of errors for some components may be characterized and analysed by their respective standard deviations.

The analysis procedure for the standard uncertainty of each component is as described in B.3.2.2.2 and B.3.2.2.3.

#### B.3.2.2.2 Uncertainty, $u_1$, of the true value for vertex power, $\Phi$

Uncertainty caused by the reference lenses is determined by the Type B evaluation. The traceable certificate giving the true value of the back vertex power will also give uncertainty of the true value $\Phi$.

If $U(\Phi)$ = 0,03 D, and $k$ = 3, then the standard uncertainty of the reference lens is:

0,03 D/3 = 0,01 D

Thus: $u_1 = u\ (\Phi)$ = 0,01 D

#### B.3.2.2.3 Uncertainty, $u_2$, of the indication reading, $d$, for vertex power, $\Phi$

##### B.3.2.2.3.1 Type A evaluation

The indication reading for vertex power given by a focimeter may be affected by the following factors.

a) Uncertainty in the indication readings given by the focimeter due to the lens centring error, the positioning error and other operator errors.



b) Uncertainty caused by the variation of temperature and humidity. This may affect the indication readings of a focimeter, especially for readings of high power.

c) Uncertainty caused by the variation of the input voltage.

d) Uncertainty caused by the influence of stray light.

e) Uncertainty caused by dust inside the lens support.

**B.3.2.2.3.2 Example of a Type A evaluation**

An automated focimeter was found to give the maximum deviation for powers around −15 D. Therefore a reference lens of nominal value of −15,00 D was used to check the repeatability. The following indication readings were obtained from six independent measurements:

−14,98 D, −14,95 D, −14,97 D, −14,94 D, −14,96 D, −14,99 D

The range among the six readings is 0,05 D.

The individual standard deviation (for $n$ = 6) may be obtained from the Bessel formula giving:

$$s = \sqrt{\frac{\sum (x_i - \bar{x})^2}{n-1}} = 0.019 \text{ D} \tag{B.5}$$

In practice, it is specified to take three independent readings, so the average value for the standard deviation is:

$$s / \sqrt{3} = 0{,}011 \text{ D}$$

Thus, the uncertainty of the indication reading for vertex power in a Type A evaluation is:

$u\,(d_A)$ = 0,011 D

**B.3.2.2.3.3 Type B evaluation**

The Type B evaluation is obtained by using an assumed probability density function.

The components for Type B evaluation include:

a) Uncertainty caused by the measuring principle and structure of the instrument itself. If the indication interval of the instrument is $\delta$ = 0,01 D, then its well-distributed area shall be:

$[-\delta/2, +\delta/2]$

and the uncertainty caused by the indication interval of the instrument is:

$(\delta/2)/\sqrt{3}$ = 0,003 D.

Thus $u(d_{B1})$ = 0,003 D.

b) Uncertainty caused by the non-symmetric error for cylindrical powers.

Non-symmetric refers to inconsistent astigmatic powers, non-direct proportional indications and irregular changes of errors given by automated focimeters at different axes of a spherocylindrical or cylindrical lens due to an over-correction by the software or other reasons. It has been shown experimentally that the maximum variation of the indication readings of vertex power is about 0,09 D.