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Optics and photonics — Test method for refractive index of optical glasses —

Part 1: Minimum deviation method

Optique et photonique — Méthode d'essai pour déterminer l'indice de réfraction des verres optiques —

Partie 1: Méthode de la déviation minimale

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Foreword

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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).

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This document was prepared by Technical Committee ISO/TC 172, *Optics and photonics*, Subcommittee SC 3, *Optical materials and components*.

A list of all parts in the ISO 21395 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

The refractive index of optical glasses has been measured by various methods, but up to now, an International Standard for the measurement has not been available. The refractive index of optical glasses is the most important characteristic for the optical elements to be manufactured from them. This document defines a suitable method for measuring the refractive index of optical glasses accurately and also helps to improve communication between raw optical glass suppliers and optical element manufacturers.

Optics and photonics — Test method for refractive index of optical glasses —

Part 1: **Minimum deviation method**

1 Scope

This document specifies the measuring method for the refractive index of optical glasses with the accuracy within 1×10^{-5} used in the spectral range from 365 nm to 2 400 nm.

Additional information on how to apply the refractive index in the dispersion and the various dispersion formulae of optical glasses is given in Annex A and Annex B.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

There are no normative references in this document.

3 Terms and definitions

No terms and definitions are listed in this document.

ISO and IEC maintain terminological databases for use in standardization at the following addresses.

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

4 Principle

As shown in Figure 1, when the monochromatic light beam is refracted by the specimen prism at the angle of minimum deviation, the relative refractive index of the specimen prism to the air at the wavelength of the monochromatic light beam is described by the following Formula (1):

$$n_{\mathrm{rel}} = \frac{\sin\frac{\alpha + \delta_{\mathrm{min}}}{2}}{\sin\frac{\alpha}{2}} \qquad (1)$$

where

n_{rel} is the relative refractive index ($n_{rel} = n_{abs}/n_{air}$);

n_{abs} is the absolute refractive index of the specimen prism;

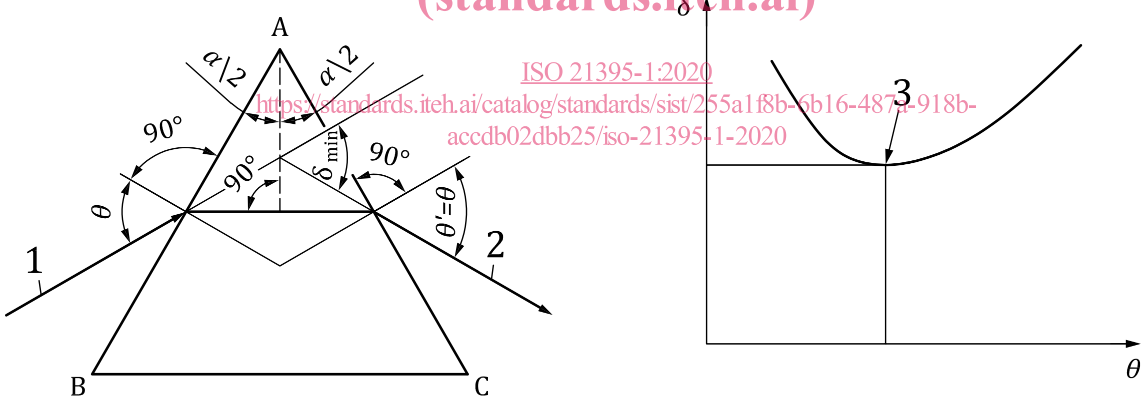
n_{air} is the refractive index of air;

α is the apex angle;

δ_{min} is the angle of minimum deviation.

As shown in Figure 1, light enters the plane AB of the specimen prism at an angle of incidence (θ) and exits from the plane AC at an exit angle (θ'). The incident and the exiting light ray form the deviation angle (δ). With the deviation angle minimized, the incident and the exiting angles are equal. The smallest angle of deviation is called the angle of minimum deviation. The angle of minimum deviation (δ_{min}) and the apex angle (α) of the specimen prism are measured, and the refractive index is calculated using those angles. Formulae for the calculation of principal dispersion, Abbe number, partial dispersion and relative partial dispersion are given in Annex A. The dispersion formulae that calculate the refractive index at the wavelength different from the measured wavelengths are given in Annex B. The correction of the refractive index of optical glasses for temperature, humidity and atmospheric pressure of optical glasses are given in Annex C.

NOTE When measuring the refractive index with this method, it is necessary to consider temperature, pressure, humidity and measurement errors. Expressions for the relations of these errors are described in ISO 17328. The dependence of the refractive index of air on temperature and pressure can be found in ISO 12123:2018, A.3.



Key

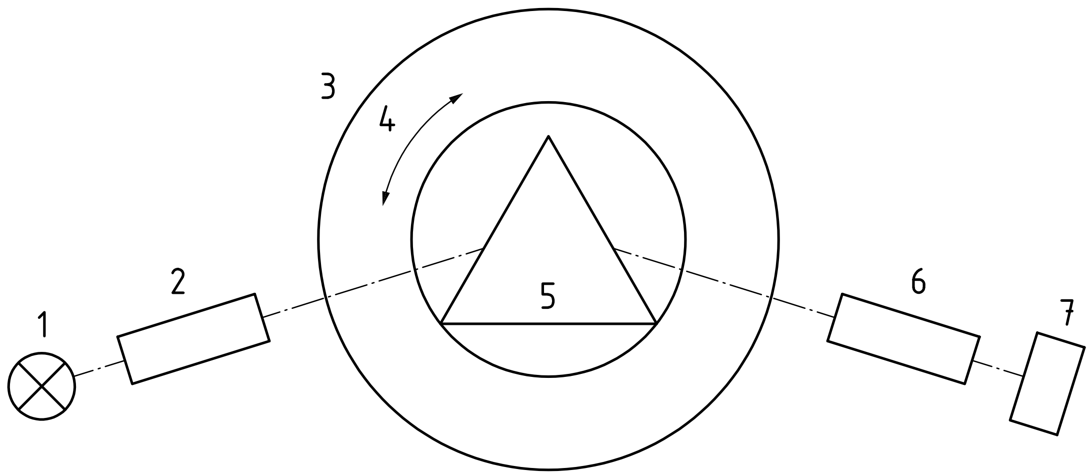
θ	angle of incidence
θ'	exit angle
α	apex angle
A, B, C	the vertices of the prism
δ_{min}	angle of minimum deviation
1	incident light
2	transmitted light
3	minimum deviation

Figure 1 — Principle of minimum deviation method

5 Measuring apparatus

5.1 General construction

The measuring apparatus is shown in Figure 2.



Key

1 light source
2 collimator
3 goniometer coupled with telescope (6) and detector (7)
4 rotating stage coupled with prism (5)
5 specimen prism
6 telescope
7 detector

Figure 2 — Schematic of minimum deviation method

5.2 Goniometer

The goniometer shall provide the capability of reading the angle within ±1 arc sec.

5.3 Light source

The light source should be a mercury, hydrogen, helium, rubidium, cesium or cadmium lamp, also He-Ne laser or Nd:YAG laser defined in ISO 7944. The spectral lines and their associated wavelengths are shown in Table 1.

Light sources and their corresponding wavelengths not defined in Table 1 are also applicable for measurement, but the spectral bandwidth of the light source and the accuracy/certainty of emission line (for example D line (589,3 nm)) should be checked before use.

Table 1 — Wavelength and spectral line of light source

Wavelength/nm	Spectral line	Light source
365,01	i	Mercury lamp
404,66	h	Mercury lamp
435,83	g	Mercury lamp
479,99	F′	Cadmium lamp
486,13	F	Hydrogen lamp
543,5	—	He-Ne laser
546,07	e	Mercury lamp
587,56	d	Helium lamp
632,8	—	He-Ne laser
643,85	C′	Cadmium lamp
656,27	C	Hydrogen lamp
706,52	r	Helium lamp

Table 1 *(continued)*

Wavelength/nm	Spectral line	Light source
780,00	—	Rubidium lamp
852,11	s	Cesium lamp
1 013,98	t	Mercury lamp
1 064,1	—	Nd:YAG laser
1 128,7	—	Mercury lamp
1 395,1	—	Mercury lamp
1 529,6	—	Mercury lamp
1 813,1	—	Mercury lamp
1 970,1	—	Mercury lamp
2 325,4	—	Mercury lamp

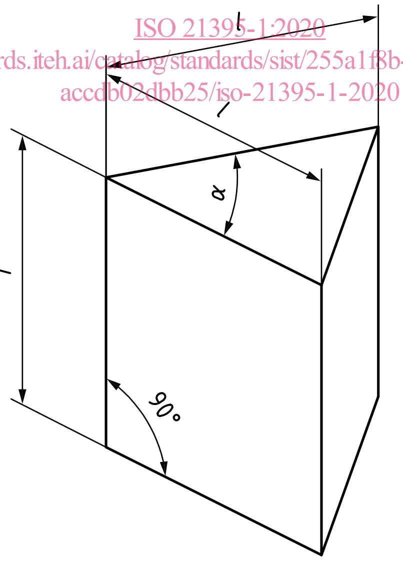
5.4 Detector

A general-type detector that is capable of detecting each wavelength or easily exchangeable for different spectral ranges should be used.

6 Specimen prism

6.1 General

An example of the shape of specimen prism is shown in Figure 3.



Key

l length
t thickness
α apex angle

Figure 3 — Shape of the specimen prism

6.2 Dimensions

The length of the edges making the apex angle should be between 15 mm and 40 mm and the thickness should be between 10 mm and 30 mm.

6.3 Apex angle

A reasonable choice of apex angle, α, for a test prism can be calculated from the expected refractive index of the prism, n_{rel}, and the angle of incidence, θ.

$$\alpha = 2\arcsin\left[\frac{\sin\theta}{n_{rel}}\right]$$

α is typically between 35° and 80°.

6.4 Flatness

The plane polished sides should have a peak to valley flatness better than ¼ λ over 80 % of the aperture at the measurement wavelength of 546 nm or 632,8 nm.

7 Environmental condition of measurement

7.1 Temperature

The temperature shall be between 20 °C and 25 °C. Environmental temperature stability and uniformity shall be controlled according to the required measurement accuracy. This requirement shall be calculated so that the temperature variation of the glass contributes no more than 50 % to the desired total measurement error. Sufficient time should be allowed for the prism to acclimatise to the test conditions prior to commencing (typically 24 h). Care should be taken in handling the prism to minimise heat transfer from the person to the prism prior to measurements.

The temperature fluctuation is less than 1/2 of required accuracy for the refractive index variation value obtained from the refractive index temperature coefficient.

NOTE In the most cases, the measurements are made at 22 °C.

EXAMPLE The refractive index change with temperature of SF57 is about $3 \cdot 10^{-5}$/K. To achieve a refractive index accuracy of $1 \cdot 10^{-5}$, the temperature fluctuation should be less than $0{,}5 \cdot \left(\frac{1 \cdot 10^{-5}}{3 \cdot 10^{-5} \cdot \frac{1}{\mathrm{K}}}\right) = 0{,}167\ \mathrm{K}$.

7.2 Humidity

The relative humidity should be between 30 % and 70 %. The fluctuation of the relative humidity during the measurement should be within ±10 %.

7.3 Atmospheric pressure

The atmospheric pressure shall be between 86 kPa and 106 kPa. The fluctuation of the pressure during the measurement should be within ±0,5 kPa.

