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Optics and photonics — Optical materials and components — Test method for homogeneity of optical glasses by laser interferometry

Optique et photonique — Matériaux et composants optiques — Méthode d'essai d'homogénéité des verres optiques par interférométrie laser

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ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

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Foreword

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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 3, *Optical materials and components*.

Optics and photonics — Optical materials and components — Test method for homogeneity of optical glasses by laser interferometry

1 Scope

This International Standard specifies the measuring method for the homogeneity of the refractive index of optical glasses by laser interferometry.

2 Normative references

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

ISO 80000-1, *Quantities and units — Part 1: General*

3 Terms and definitions

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

3.1
homogeneity of the refractive index
maximum of the refractive index variations excluding linear changes among refractive index variations within the predetermined area in a single glass sample

3.2
index-matching liquid
transparent liquid with the refractive index which is equivalent or approximate to the refractive index of a glass sample at the wavelength of the laser to be used

3.3
flatness correction plate
plane-parallel plate obtained by polishing an optical glass with high homogeneity to a high degree of accuracy, e.g. 1/20 of a laser wavelength, which is stuck to a sample by using an index-matching liquid as an intermediate liquid, for the purpose of correcting the flatness of the sample

3.4
PV value of wavefront
difference between the maximum and the minimum deviations of the wavefront, observed when light transmits through a sample once with an interferometer from the approximated plane

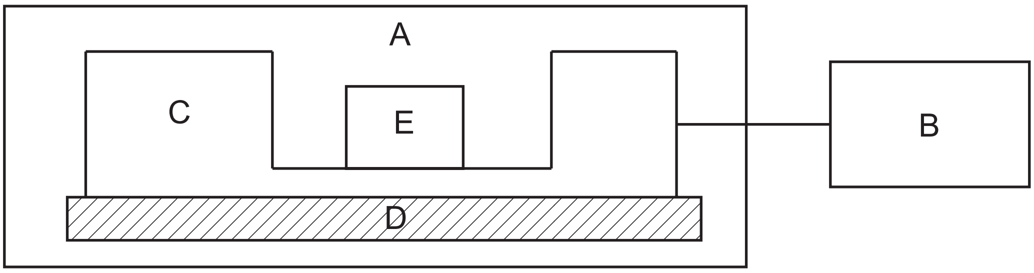
4 Principle

The PV value of wavefront of a luminous flux that transmitted through a sample with sufficient flatness is measured using a laser interferometer, and the homogeneity of the refractive index of the sample is obtained.

5 Measuring apparatus

5.1 General

The measuring apparatus shall be as shown in Figure 1 and as specified in 5.2 to 5.5.



Key

A thermostatic chamber

B interferogram analysis device

C laser interferometer

D vibration isolation device

E sample

Figure 1 — Example of composition of measuring apparatus

5.2 Laser interferometer

The laser interferometer to be used shall have a laser as a light source and an optical system in which the wavefront of a luminous flux forms a plane. Examples of such interferometers are given in Annex A.

5.3 Interferogram analysis device

The interferogram analysis device to be used shall be capable of obtaining the PV value of wavefront from an interferogram.

5.4 Thermostatic chamber

The thermostatic chamber to be used shall be capable of maintaining the interferometer and the sample at a certain temperature. The temperature of the standard atmospheric conditions shall be 20 °C, 22 °C, 23 °C, or 25 °C depending on the purpose of testing. The tolerance of the temperatures of the standard atmospheric conditions should be ±0,2 °C. See Annex B.

5.5 Vibration isolation device

The vibration isolation device to be used shall be capable of eliminating the effect of vibration from the outside to the interferometer and the sample system. It should be provided for performing high accuracy measurements.

6 Preparation of sample

The sample shall be cylindrical or prismatic, and its thickness (height) direction shall be the direction of observation (which is the direction of the optical axis of the luminous flux of an interferometer). The thickness in the direction of observation shall be sufficient to obtain an accurate measured value.

Both end faces (the faces vertical to the optical axis) of a sample shall be polished so that the flatness of not more than 1/20 of a laser wavelength (when the wavelength is 632,8 nm, approximately 0,032 µm) is obtained.

When the above-mentioned precision polishing is not performed, flatness correction plates shall be stuck to the sample using an index-matching liquid as an intermediate liquid, to be supplied for measurement. An example of using flatness correction plates is given in Annex C. In this case, the refractive index of the index-matching liquid should conform to that of the sample so that the measurement of homogeneity is not affected. The difference of refractive indices between index-matching liquid and the sample should be approximately 0,005 or less. See Annex B.

Furthermore, in order to bond the flatness correction plates to the sample stably using the refractive index-matching liquid, the flatness of the sample should be approximately 20 µm or less. See Annex D.

7 Operation

The operation shall be performed as follows.

a) Remove dirt from the sample surfaces and correction plates, if used.

b) Install the sample in the interferometer so that the predetermined area of the sample fits within the luminous flux of the interferometer. When using flatness correction plates, stick the flatness correction plates to the sample with the index-matching liquid inserted between the sample surfaces and the flatness correction plates. While doing this, do not allow air bubbles in the intermediate liquid.

c) Leave the installed sample to stand until its temperature has returned to the temperature of the measurement environment as given in 5.4. When using flatness correction plates, allow the installed sample with plates to stand until the thickness of the layer of the refractive index-matching liquid between the matched surfaces no longer changes.

d) Adjust the optical system of the interferometer so that the number of interference fringes of an interferogram becomes appropriate, and then perform the measurement.

e) Obtain the PV value of wavefront of the luminous flux which transmitted through the sample measuring system from the interferogram.

8 Measurement

The measurement shall be performed as follows.

a) The measurement should be performed twice or more by repeating the series of operations described in Clause 7(d) and Clause 7(e). When the average is taken as a measured value, it should be stated in the test report.

b) The wavefront irregularities of the optical system of the interferometer and the wavefront irregularities due to the homogeneity of the refractive index and the flatness of a flatness correction plate contribute errors to the test results. Therefore, for the wavefront of the luminous flux which transmitted through the sample, these errors should be corrected, and the PV value of wavefront should be obtained from the wavefront after correction. An example of the measurement of the PV value of wavefront is given in Annex E.

9 Calculation

The calculation of the test result shall be performed as follows.

a) The homogeneity of the refractive index shall be calculated according to Formula (1).

$$\Delta n = \frac{P_V \cdot \lambda}{t} \quad (1)$$

where

Δn is the homogeneity of the refractive index;

P_V is the PV value of wavefront (wavelength unit);

λ is the wavelength of laser (mm);

t is the thickness of sample (mm).

b) For reporting, the homogeneity of the refractive index shall be rounded to two significant figures in accordance with ISO 80000-1. However, when it is less than 10^{-6}, it shall be rounded to one significant figure.

EXAMPLE An example of a calculation is shown below.

P_V is 0,049 (λ);

λ is 632,8 × 10^{-6} (mm);

t is 41 mm.

The Formula (2) is given

$$\begin{aligned} \Delta n &= \frac{P_V \cdot \lambda}{t} \\ &= \frac{0{,}049 \times 632{,}8 \times 10^{-6}}{41} \\ &= 0{,}756 \times 10^{-6} \left(\text{Since it is less than } 10^{-6}\text{, it is rounded to one significant figure.}\right) \\ \Delta n &= 8 \times 10^{-7} \end{aligned} \quad (2)$$

10 Test report

For the measurement result, the following items shall be reported:

a) measurement date (year/month/day);

b) measuring location;

c) measuring apparatus, type of interferometer and wavelength of laser;

d) name of the measurer;

e) temperature of measurement;

f) thickness, shape and measurement area of sample;

g) method of sample measuring system (whether or not the sample was used with the flatness correction plates);

h) whether or not correction was performed for the wavefront irregularities of the optical system of the interferometer or wavefront irregularities due to the inhomogeneity of the refractive index and flatness of the flatness correction plate;

i) value of homogeneity of the refractive index (in the case of reporting the average, the number of measurements performed);

j) furthermore, a representative photograph of interference fringes of a sample should be attached where possible;

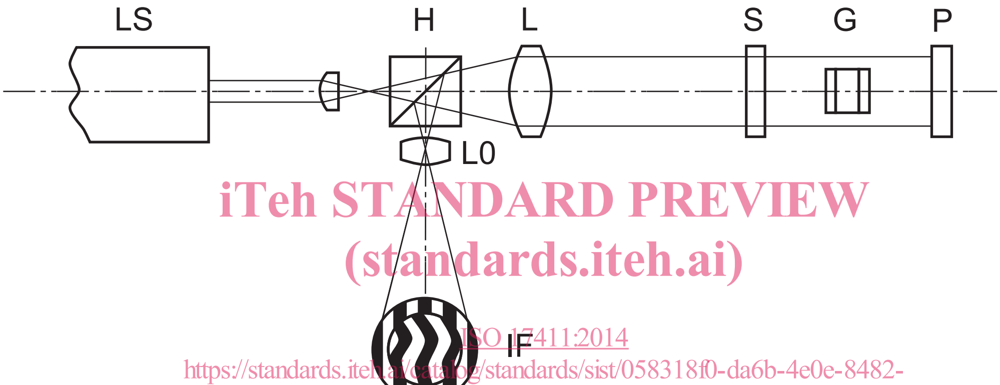
k) other special conditions to be noted.

Annex A
(informative)

Laser interferometer

The laser interferometer is a device that generates interference fringes by splitting the parallel rays with uniform wavefronts into two with a semi-transparent plane mirror (beam splitter), and after making each ray pass through difference paths, shifts the wavefronts slightly and then superimposes them again.

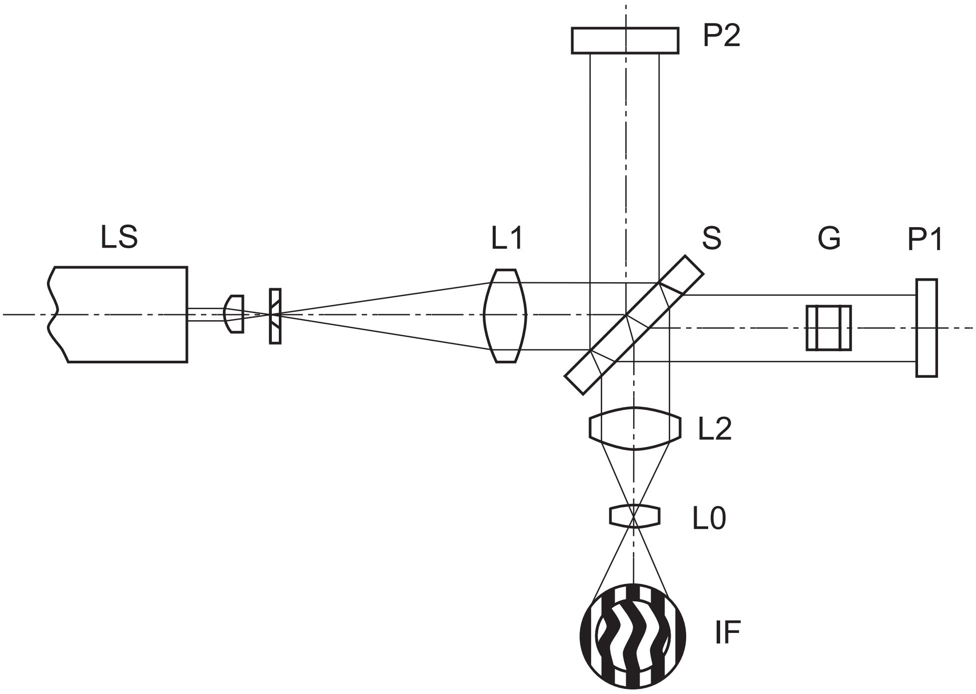
As examples of devices suitable for the homogeneity measurement of glass, three types of interferometers are shown below. Figures A.1 and A.2 show interferometers of the type in which a luminous flux transmits through the sample twice, and Figure A.3 shows interferometer of the type in which a luminous flux transmits through the sample once.



Key

G glass sample
H beam splitter
L collimating lens
L0 imaging lens
LS light source
P plane mirror
S beam splitter
IF interference fringes

Figure A.1 — Fizeau interferometer



Key

G	glass sample
L0	imaging lens
L1, L2	collimating lens
LS	light source
P1, P2	plane mirror
S	beam splitter
IF	interference fringes

Figure A.2 — Twyman-Green interferometer