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Raw optical glass in bulk and preshaped forms — Bubbles and other inclusions — Test method and classification

*Verre d'optique brut sous forme de bloc et préformé — Bulles et autres
inclusions — Méthode d'essai et classification*



Reference number
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Introduction

The harmful effect of bubbles and other inclusions (in the following text only the term “inclusions” is used) on optical performance is proportional to the projected cross-sectional area of the inclusions. In a pupil plane the inclusions scatter light in proportion to their area. In an image plane, inclusions are objectionable due to their visibility and therefore their cross-sectional area.

For these reasons, glass in bulk form has traditionally been graded for inclusion quality in terms of the apparent cross-sectional area of inclusions per unit volume of glass.

This International Standard, however, can also be used for an individual glass in preshaped form (e.g. moulded, or prepared for machining, or having a specific shape).

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Raw optical glass in bulk and preshaped forms — Bubbles and other inclusions — Test method and classification

1 Scope

This International Standard specifies a test method for determining inclusions in raw optical glass in bulk and preshaped form.

It gives a classification for raw optical glass in bulk form according to inclusions determined by the test method specified, as well as a designation of a raw optical glass in preshaped form according to the inclusions determined by this test method.

2 Definitions

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

2.1 inclusion: Extraneous or foreign material (for instance bubble, seed, knot, stone) present within the body of the glass.

NOTE — Inclusions may occur in glass as a result of the manufacturing process and, in general, have approximately circular cross-sections.

2.2 bubble: A gaseous inclusion in glass (gas-filled cavity).

NOTE — See also definitions of “blister” and “seed” in ISO 9802.

2.3 concentration (of inclusions in a raw optical glass of preshaped form): Occurrence of inclusions within a subarea of 4 % of the total test area, of more than 20 % of the total number of inclusions. For example, if the total number of inclusions is less than 10, then two or more inclusions falling within a 4 % subarea constitute a concentration. In the case of a circular test area, its diameter corresponds to 1/5 of the diameter of the preshaped form.

3 Principle

3.1 For raw optical glass in bulk form, determination of the total cross-sectional area of all accountable inclusions per 100 cm³ of glass.

3.2 For a raw optical glass in preshaped form, determination of the number and diameter of accountable inclusions present in any intended optical path through the glass.

4 Apparatus

4.1 Travelling microscope with scale.

4.2 Dark field illumination.

5 Test sample

The test sample shall have at least one polished, preferably plane surface.

6 Procedure

6.1 The test sample to be inspected is illuminated by a beam of light from the side, and viewed against a dark background. Inclusions will appear as bright specks on a dark field.

6.2 For raw optical glass in bulk form, determine the number and diameter of all inclusions which are not less than 0,063 mm in size, and the volume of the test sample.

6.3 For raw optical glass in preshaped form, determine the number and diameter of all accountable inclusions, the minimum accountable size being 1/4 of the maximum permissible size.

In case of non-circular cross-section inclusion, the diameter in millimetres is equal to the geometric mean of the shortest and the longest diameter.

7 Expression of results

7.1 Raw optical glass in bulk form

Calculate the total cross-sectional area in square millimetres of the accountable inclusions per 100 cm³ of the test sample.

7.2 Raw optical glass in preshaped form

Refer to table 1 which gives the inclusion grade number, A, equal to the diameter, in millimetres, of the maximum size inclusion permitted or present in the test sample.

Several inclusions smaller than the maximum size inclusion are allowed if, in total, the cross-sectional area of the maximum size inclusion is not exceeded. Table 1 provides subdivision factors by which the number of smaller inclusions are to be divided so that the inclusion quality can be expressed in terms of the number of maximum size inclusions (see example 2 in 8.2).

For subdivision of a permissible number of inclusions (with an inclusion grade number A, according to the first column of table 1) into smaller inclusions (with an inclusion grade number A, according to column two, three, four or five of table 1), the permissible number is to be multiplied by the subdivision factor of the corresponding column, see the following example.

EXAMPLE

Two inclusions having an inclusion grade number A, of 0,63 may be subdivided into

$$2 \times 2,5 \hat{=} 5 \text{ inclusions of } A = 0,40$$

or

$$2 \times 6,3 \hat{=} 13 \text{ inclusions of } A = 0,25$$

Table 1 — Inclusion grade numbers, diameters and subdivision factors

Inclusion grade number A	Range and nominal values of diameter, in millimetres, of accountable inclusions			
	A to over 0,8 A	0,8 A to over 0,5 A	0,5 A to over 0,3 A	0,3 A and below
	A	0,63 A	0,40 A	0,25 A
0,004	0,004	—	—	—
0,006	0,006	0,004	—	—
0,010	0,010	0,006	0,004	—
0,016	0,016	0,010	0,006	0,004
0,025	0,025	0,016	0,010	0,006
0,040	0,040	0,025	0,016	0,010
0,063	0,063	0,040	0,025	0,016
0,10	0,10	0,063	0,040	0,025
0,16	0,16	0,10	0,063	0,040
0,25	0,25	0,16	0,10	0,063
0,40	0,40	0,25	0,16	0,10
0,63	0,63	0,40	0,25	0,16
1,0	1,0	0,63	0,40	0,25
1,6	1,6	1,0	0,63	0,40
2,5	2,5	1,6	1,0	0,63
4,0	4,0	2,5	1,6	1,0
Subdivision factors	1	2,5	6,3	16

Subdivision of one inclusion into more than 16 smaller inclusions and smaller than a diameter of 0,004 mm is not permitted.

Partial subdivisions are allowed. That is, a fraction of the permissible number of inclusions may be subdivided according to the above paragraph.

These subdivision factors are calculated from the nominal diameter of an inclusion smaller than the maximum permitted size. Thus for A = 0,40, allowing a maximum inclusion size of 0,4 mm, the subdivision factor for inclusions 0,25 mm in diameter is 2,5.

Where inclusions are observed with a size not listed in table 1, for practical purposes, the diameter range embracing the actual size is selected to determine the subdivision factor. Thus for A = 0,40 an inclusion 0,3 mm in diameter equal to 0,75 A would have a subdivision factor of 2,5, and an inclusion 0,15 mm in diameter equal to 0,38 A would have a subdivision factor of 6,3.

8 Classification and designation

8.1 Raw optical glass in bulk form

Raw optical glass in bulk form shall be classified in accordance with table 2.

Table 2 — Classification of raw optical glass in bulk form

Inclusion class	Total cross-sectional area of inclusions per 100 cm ³ of glass mm ²
IC 0	up to and including 0,03
IC 1	more than 0,03 up to and including 0,1
IC 2	more than 0,1 up to and including 0,25
IC 3	more than 0,25 up to and including 0,5
IC 4	more than 0,5

For convenience of reference to the inclusions of raw optical glass in bulk form complying with the classification of this International Standard, the use of a designation as follows is recommended:

EXAMPLE

The designation of a raw optical glass in bulk form having a total cross-sectional area of inclusions of 0,06 mm² per 100 cm³ of glass (class IC 1) shall be:

Optical glass in bulk form, inclusion class ISO 12123 - IC 1

8.2 Raw optical glass in preshaped form

For convenience of reference to the inclusions of individual raw optical glass in preshaped form complying with the determination of this International Standard, the use of a designation as follow is recommended:

EXAMPLE 1

The designation of a raw optical glass in preshaped form containing $n = 4$ inclusions with an inclusion grade number $A = 0,16$ shall be:

Optical glass in preshaped form, inclusion code ISO 12123 - $1/4 \times 0,16$

EXAMPLE 2

The designation of a raw optical glass in preshaped form containing inclusions of different sizes, for example

1 inclusion at 0,25 mm

3 inclusions at 0,16 mm

6 inclusions at 0,1 mm

16 inclusions at 0,063 mm

$A = 0,25$ mm (maximum size)

$n = 1 + 3/2,5 + 6/6,3 + 16/16 \approx 4$ (to the nearest whole number)

shall be:

Optical glass in preshaped form, inclusion code ISO 12123 - $1/4 \times 0,25$

9 Test report

The test report shall include the following information:

- a) reference to this International Standard;
- b) identification of the test sample;
- c) for raw optical glass in bulk form, designation of the inclusion class (IC);
- d) for a raw optical glass in preshaped form: designation of the inclusion code ($1/n \times A$) and a statement of whether or not there are concentrations (see 2.3).

Annex A (informative)

Bibliography

- [1] ISO 9802:1996, *Raw optical glass — Vocabulary*.

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