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**Optics and optical instruments —  
Preparation of drawings for optical  
elements and systems —**

**Part 3:**  
Material imperfections — Bubbles and  
inclusions

*Optique et instruments d'optique — Indications sur les dessins pour  
éléments et systèmes optiques —*

*Partie 3: Imperfections des matériaux — Bulles et inclusions*

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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.

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 10110-3 was prepared by Technical Committee ISO/TC 172, *Optics and optical instruments*, Subcommittee SC 1, *Fundamental standards*.

ISO 10110 consists of the following parts, under the general title *Optics and optical instruments — Preparation of drawings for optical elements and systems*:

- Part 1: *General*
- Part 2: *Material imperfections — Stress birefringence*
- Part 3: *Material imperfections — Bubbles and inclusions*
- Part 4: *Material imperfections — Inhomogeneity and striae*
- Part 5: *Surface form tolerances*
- Part 6: *Centring tolerances*
- Part 7: *Surface imperfection tolerances*
- Part 8: *Surface texture*
- Part 9: *Surface treatment and coating*

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- Part 10: Table representing data of a lens element
- Part 11: Non-toleranced data
- Part 12: Aspheric surfaces
- Part 13: Laser irradiation damage threshold

Annex A of this part of ISO 10110 is for information only.

# Optics and optical instruments — Preparation of drawings for optical elements and systems —

## Part 3: Material imperfections — Bubbles and inclusions

### 1 Scope

ISO 10110 specifies the presentation of design and functional requirements for optical elements and systems in technical drawings used for manufacturing and inspection.

This part of ISO 10110 specifies the indication of the level of acceptability of bubbles and other inclusions in optical elements.

### 2 Definitions

For the purposes of this part of ISO 10110, the following definitions apply.

**2.1 bubbles:** Gaseous voids in the bulk material, of generally circular cross section, which sometimes appear in glass as the result of the manufacturing process.

**2.2 other inclusions:** All localized bulk material defects of essentially circular cross section, including striae knots, small stones, sand and crystals.

### 3 Permissible bubbles and other inclusions

As a result of the glass melting and refining process, bubbles and other inclusions appear in roughly constant numbers per unit volume of glass. Their number depends on the glass type and the manufacturing process.

The harmful effect of bubbles and inclusions on optical performance is roughly proportional to their projected cross-sectional area:

- bubbles and other inclusions scatter light in proportion to their area;
- near an image plane, bubbles and other inclusions are objectionable due to their visibility and therefore their cross-sectional area.

For these reasons, glass has traditionally been graded for bubble quality in terms of the apparent cross-sectional area of bubbles and other inclusions per unit volume of glass; however, this part of ISO 10110 applies to individual optical elements.

### 3.1 Specification

The specification for bubbles and other inclusions which are permissible in the element is given in the form  $N \times A$ :

$N$  is the number of bubbles and inclusions of maximal permitted size allowed;

the grade number  $A$  is the measure of their size. It is equal to the square root of the projected area of the largest permissible bubble and/or inclusion, expressed in millimetres. Preferred values for  $A$  are given in the first column of table 1.

### 3.2 Sub-division

A larger number of bubbles and other inclusions with a smaller grade number is permitted if the sum of the

projected areas of all bubbles and inclusions does not exceed

$$N \times A^2 \text{ (= maximum total area)}$$

Grade numbers are given in the columns of table 1, and the corresponding multiplication factors appear in the first line of the table.

The table indicates, for example, that six bubbles of grade number 0,10 have the same area as one bubble of grade number 0,25.

When determining the number of permissible bubbles and other inclusions, those with a grade number of 0,16  $A$  or smaller shall not be counted.

### 3.3 Concentrations

Concentrations of bubbles and other inclusions are not allowed. A concentration occurs when more than 20 % of the number of allowed bubbles and other inclusions is found in any 5 % of the test region. If the total number of bubbles and other inclusions is less than 10, then 2 or more bubbles or other inclusions falling within a 5 % sub-area constitute a concentration.

## 4 Indication in drawings

4.1 The indication of bubbles and other inclusions which are permissible in the element is given by a code number and a numerical term.

4.2 The code number for bubbles and other inclusions is 1.

4.3 The indication is given in the form:  $1/N \times A$ .

4.4 The term  $N \times A$  is determined in accordance with clause 3.

4.5 The indication shall be entered near the optical element to which it refers. If necessary, the indication may be connected to the element by a leader. It should preferably be associated with the other indications of material imperfections (stress birefringence, inhomogeneity, and striae; see ISO 10110-2 and ISO 10110-4).

Alternatively, for lens elements, the indication may be given in a table in accordance with ISO 10110-10.

## 5 Example

(see also ISO 10110-1:1996, annex A)

Figure 1 shows, as an example, the indication of a maximum of 3 permissible bubbles or other inclusions of grade number 0,16.

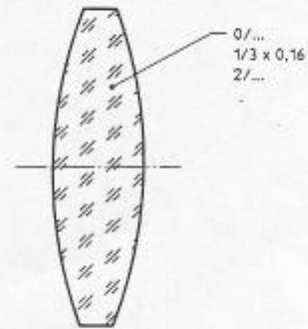


Figure 1 — Example of tolerance indication for bubbles and other inclusions

Table 1 — Preferred size designation and factors for sub-division for bubbles and other inclusions

	Multiplication factors			
	1 (preferred values)	2,5	6,3	16
Grade numbers <i>A</i> mm	0,006			
	0,010	0,006		
	0,016	0,010	0,006	
	0,025	0,016	0,010	0,006
	0,040	0,025	0,016	0,010
	0,063	0,040	0,025	0,016
	0,10	0,063	0,040	0,025
	0,16	0,10	0,063	0,040
	0,25	0,16	0,10	0,063
	0,40	0,25	0,16	0,10
	0,63	0,40	0,25	0,16
	1,0	0,63	0,40	0,25
	1,6	1,0	0,63	0,40
	2,5	1,6	1,0	0,63
4,0	2,5	1,6	1,0	

EXAMPLE

If the indication is  $1/2 \times 0,25$  (i.e. 2 bubbles of grade number 0,25), then  $2 \times 2,5 \approx 5$  bubbles and/or other inclusions of grade number 0,16, or  $2 \times 6,3 \approx 12$  bubbles of grade number 0,1 or  $2 \times 16 \approx 32$  bubbles of grade number 0,063 are permissible. Alternatively, any corresponding combination of the above is permissible, provided that the total projected area of all bubbles and/or other inclusions with a grade number greater than  $0,16 \times 0,25 = 0,04$  does not exceed  $2 \times 0,25^2 \text{ mm}^2 = 0,125 \text{ mm}^2$ .

## Annex A (informative)

### Bibliography

- [1] ISO 10110-1:1996, *Optics and optical instruments — Preparation of drawings for optical elements and systems — Part 1: General*.
- [2] ISO 10110-2:1996, *Optics and optical instruments — Preparation of drawings for optical elements and systems — Part 2: Material imperfections — Stress birefringence*.
- [3] ISO 10110-4:—<sup>1)</sup>, *Optics and optical instruments — Preparation of drawings for optical elements and systems — Part 4: Material imperfections — Inhomogeneity and striae*.
- [4] ISO 10110-10:1996, *Optics and optical instruments — Preparation of drawings for optical elements and systems — Part 10: Table representing data of a lens element*.

1) To be published.

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