INTERNATIONAL STANDARD

ISO 10110-7

Second edition
2008-02-15

Optics and photonics — Preparation of drawings for optical elements and systems —

Part 7: Surface imperfection tolerances

Optique et photonique — Indications sur les dessins pour éléments et systèmes optiques —

Partie 7: Tolérances d'imperfection de surface

Reference number
ISO 10110-7:2008(E)

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Published in Switzerland

Foreword

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International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. 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.

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.

ISO 10110-7 was prepared by Technical Committee ISO/TC 172, *Optics and photonics*, Subcommittee SC 1, *Fundamental standards*.

This second edition cancels and replaces the first edition (ISO 10110-7:1996), which has been technically revised.

ISO 10110 consists of the following parts, under the general title *Optics and photonics — 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*

— *Part 10: Table representing data of optical elements and cemented assemblies*

— *Part 11: Non-toleranced data*

— *Part 12: Aspheric surfaces*

— *Part 14: Wavefront deformation tolerance*

— *Part 17: Laser irradiation damage threshold*

Introduction

A localized surface imperfection, such as a dig or a scratch resulting from handling or manufacture, can degrade the perceived quality of an optical component. Dark-field inspection reveals the location of very small imperfections. The use of an appearance comparison scale, together with tolerance levels agreed by the manufacturer and user, permits classification of a component as “accept” or “reject”. This form of subjective inspection based on visibility or a visual assessment of area, although economic and fast, lacks precision.

Measurement is only required as a second stage operation following inspection necessary to determine location and to select a surface imperfection worthy of study, see ISO 14997. In such cases, a drawing notation indicating this level of inspection is required and can be added to the specification. This process, not depending on the eye, is more time consuming and is usually only carried out when a surface imperfection could influence performance as, for example, in laser or low-light level systems or when a more precise measure is demanded.

Optics and photonics — Preparation of drawings for optical elements and systems —

Part 7: Surface imperfection tolerances

1 Scope

ISO 10110 specifies the presentation of design and functional requirements for single optical elements and for optical assemblies in technical drawings used for their manufacture and inspection.

This part of ISO 10110 specifies the indication of the level of acceptability of surface imperfections within the effective aperture of individual optical elements and optical assemblies. These include localized surface imperfections, edge chips and long scratches.

It is to be noted that the acceptance level for localized imperfections is specified taking into account functional effects (affecting image formation or durability of the optical element) as well as cosmetic (appearance) effects.

This part of ISO 10110 applies to transmitting and reflecting surfaces of finished optical elements, whether or not they are coated, and to optical assemblies. It recognizes that permissible imperfections may be specified according to the area affected by imperfections on components or in optical assemblies.

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 10110-1:2006, *Optics and photonics — Preparation of drawings for optical elements and systems — Part 1: General*

ISO 14997:2003, *Optics and optical instruments — Test methods for surface imperfections of optical elements*

3 Terms and definitions

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

See Figure 1 for an illustration of the classification of imperfections.

3.1
localized surface imperfection
localized artifact within the effective aperture of an optical surface, optical element or optical assembly produced by improper treatment during or after fabrication or in use

NOTE 1 Examples of localized artifacts are scratches, pits, sleeks, scuffs and fixture marks. Also included are localized coating blemishes such as grey spots and colour sites that absorb or reflect light differently from the bulk of the coating. Imperfections can be on or under a surface. ISO 9802 includes a glossary of terms in use.

NOTE 2 Surface imperfections in optical assemblies can occur on any surface of the assembly.

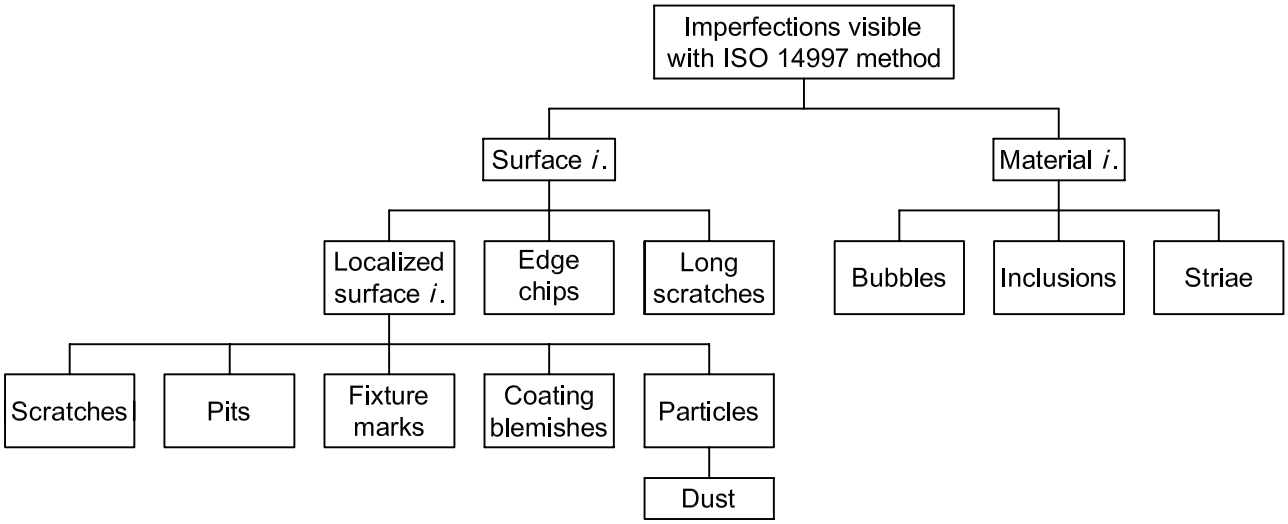

Figure 1 — Classification of imperfections

3.2
long scratch
thin surface imperfection longer than 2 mm

NOTE These tend to be more visible than shorter defects of the same width because of their length.

3.3
edge chip
localized artifact around the periphery of an element

NOTE Even if edge chips are outside the optically effective area, they can detrimentally affect the performance of optical systems by disturbing the sealing of elements, or by giving rise to a source of scattered light or to sites of crack propagation.

4 Indication in drawings

4.1 General

A code number and a numerical term give the indication of permissible surface and localized imperfections. The code number for surface imperfections is 5/ and the code number for surface imperfections in optical assemblies is 15/.

In ISO 14997:2003 Method I, a hierarchy of inspection levels is described. Preference for visual comparison only (level 2 inspection), or an objective measurement only (level 7 inspection) may be recorded with a notation as described in 4.2.4.

4.2 Affected area method for optical elements and assemblies

4.2.1 Surface imperfections

4.2.1.1 General

The drawing indication for number and size of surface imperfections, which are permissible within the effective aperture of a surface, is

$$5/N \times A$$

and for localized surface imperfections in optical assemblies it is

$$15/N \times A$$

The indication in the form $N \times A$ specifies the number, N, of allowed imperfections of maximum permitted size, and the grade number, A, which is equal to the square root of the area of the maximum allowed imperfection, expressed in millimetres.

4.2.1.2 Coating blemishes

It is possible to specify the level of acceptability of coating blemishes separately from that of the localized surface imperfections, if desired.

Following the indication for surface imperfections and separated from it by a semicolon, the indication for coating blemishes, which are permissible within the effective aperture of a surface or assembly, is

$$\mathrm{C}N' \times A'$$

where

C is the designation for coating blemishes;

N' is the number of allowed blemishes of maximum permitted size;

A' is the grade number as defined in 4.2.1.1.

The imperfection indication including coating blemishes is

$$5/N \times A;\ \mathrm{C}N' \times A'$$

for surfaces and

$$15/N \times A;\ \mathrm{C}N' \times A'$$

for assemblies.

If no separate indication for coating blemishes is given, it shall be included in the permissible surface imperfection indication:

$$5 \text{ or } 15/N \times A$$

4.2.1.3 Long scratches

Following the indication for surface imperfections (and coating blemishes, if given) and separated from them by a semicolon, the indication for long scratches (longer than 2 mm), which are permissible within the effective aperture of a surface, is

$$\mathrm{L}N'' \times A''$$

where

L is the indication for long scratches;

N'' is the number of allowed long scratches and the grade number;

A'' specifies the maximum allowed width of the scratches, expressed in millimetres.

The imperfection indication including coating blemishes and long scratches is

5 or 15/$N \times A$; C$N' \times A'$; L$N'' \times A''$

If no separate indication for long scratches or coating blemishes is given, it shall be included in the permissible surface imperfection indication:

5 or 15/$N \times A$

4.2.1.4 Edge chips

Following the indication for surface imperfections (and coating blemishes, and/or long scratches, if given) and separated from them by a semicolon, the indication for permissible edge chips is

EA'''

where E is the designation for edge chips, and the grade number A''' specifies the maximum permissible extent of a chip from the physical edge of the surface, or cell in the case of an optical assembly, measured parallel to the surface, in millimetres. Any number of edge chips is permissible as long as their extent from the edge does not exceed A'''.

If no explicit indication for edge chips is given, edge chips are allowed as long as they do not extend into the optical effective diameter.

4.2.1.5 Surface imperfection indication

The complete imperfection indication, including coating blemishes, long scratches and edge chips is

5 or 15/$N \times A$; C$N' \times A'$; L$N'' \times A''$; EA'''

To summarise:

5/	represents surface imperfections and 15/ represents surface imperfections in assemblies, respectively;
$N \times A$	for surface imperfections;
C$N' \times A'$	for coating blemishes;
L$N'' \times A''$	for long scratches;
EA'''	for edge chips.

NOTE Indications in the form 5/TV and 5/RV are indications of Method II of the first edition of this International Standard (ISO 10110-7:1996).

If more than one type of surface imperfection is given, these surface imperfections or localized imperfections in optical assemblies are permissible independent of each other.

4.2.2 Imperfections with a smaller grade number

A larger number of surface imperfections (including coating blemishes) with a smaller grade number is permitted, if the sum of their areas does not exceed the maximum total area.

$N \times A^2$	for surface imperfections;
$N' \times A'^2$	for coating blemishes.

When determining the number of permissible surface imperfections or localized imperfections in optical assemblies, those with a grade number of 0,16A or smaller shall not be counted.

A larger number of long scratches is allowed, provided that the sum of their widths does not exceed $N'' \times A''$. In calculating this sum, scratches with widths less than 0,3A'' shall not be counted.

4.2.3 Concentrations of surface imperfections

Concentrations of surface imperfections are not allowed. A concentration occurs when more than 20 % of the number of allowed defects is found in any 5 % of the test region. If the total number of imperfections is less than ten, then two or more imperfections falling within a 5 % sub-area of the surface (which has a similar form as the test area) constitute a concentration.

4.2.4 Test method

The method for inspecting surfaces and for measuring grade numbers of imperfections is described in ISO 14997.

Inspection, as indicated in Annex D of ISO 14997:2003, may be carried out along one of three routes specified in the indication for surface imperfections (and coating blemishes, long scratches and/or edge chips, if given) and separated from them by a semicolon, as follows.

Route 1, typically for mass-produced optics, stops at level 2. The indication is IV.

Route 2 employs subjective comparison of grades with lines and dots of known dimensions. The indication is IS.

Route 3 employs objective measurement of grades. The indication is IO.

EXAMPLES If visual inspection only is required, this would be indicated by IV. If the grades of imperfections are assessed by subjective comparison this will be indicated by IS. IO will be used if objective comparison is specified.

4.3 Location

The indication shall be entered near the surface 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 surface tolerance (surface form tolerance and centring tolerance). An example of such an indication is given in Annex A of ISO 10110-1:2006.

If two or more optical elements are to be cemented (or optically contacted), the surface imperfection tolerances given for the individual elements apply also for the surfaces of the optical sub-assembly, i.e. after cementing (or optically contacting), unless otherwise specified. See 4.8.3 of ISO 10110-1:2006.

Bibliography

[1] ISO 9802, *Raw optical glass — Vocabulary*

ICS 01.100.20; 37.020

Price based on 6 pages