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

Part 7: Surface imperfections

Optique et photonique — Indications sur les dessins pour éléments et systèmes optiques —
Partie 7: Imperfections de surface

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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.

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).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

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

This third edition cancels and replaces the second edition (ISO 10110-7:2008), which has been technically revised.

The main changes compared to the previous edition are as follows:

— an additional notation has been added which allows the specification of a maximum allowable width for imperfections;

— long imperfection accumulation rules have been corrected to coincide with the Renard series of grades;

— the rules for determining concentrations have been clarified;

— the test method notations and meanings have been clarified;

— an additional notation has been added which allows the use of the popular scratch and dig specification for cosmetic surface imperfections;

— in addition, several changes have been made to bring this document into alignment with the inspection methods for surface imperfections which are described in ISO 14997, and various editorial corrections have been made throughout this document.

A list of all parts in the ISO 10110 series can be found on the ISO website.

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. In some cases, surface imperfections are specified according to their visibility, and in other cases, according to their size.

Visual dark field inspection reveals the location of very small imperfections. The use of a brightness comparison standard, together with tolerance levels agreed upon by the manufacturer and user, permits classification of an imperfection as acceptable or unacceptable. This form of subjective inspection based on visibility or a visual assessment of brightness or apparent size, although economical and fast, lacks precision.

In cases where the size, and not the brightness, is important, surface imperfections are specified according to their affected area (dimensional assessment). In this case, visual assessment using a dimensional comparison standard is still possible, but lacks the precision required for some applications. Measurement is only required as a second stage operation following a visual inspection to determine location and to select a surface imperfection worthy of study. In such cases, a drawing notation indicating this level of inspection is required and can be added to the specification.

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

Part 7: Surface imperfections

1 Scope

ISO 10110 (all parts) 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 document specifies the indication of the level of acceptability of surface imperfections within a test region on individual optical elements and optical assemblies. These include localized surface imperfections, edge chips and long scratches.

The acceptance level for imperfections is specified, taking into account functional effects (affecting image formation or durability of the optical element), as well as cosmetic (appearance) effects.

This document applies to transmitting and reflecting surfaces of finished optical elements, whether or not they are coated, and to optical assemblies. It allows permissible imperfections to be specified according to the area affected by imperfections, or alternatively by the visibility of imperfections, on components or in optical assemblies.

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.

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

ISO 14997, *Optics and photonics — Test methods for surface imperfections of optical elements*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 10110-1 and the following apply.

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

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

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

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

3.1
localized surface imperfection
artefact of limited extent within a test region on an optical surface, optical element or optical assembly produced by improper treatment during or after fabrication or in use, or by a material imperfection located at the surface

Note 1 to entry: Examples of localized artefacts are scratches, pits, sleeks, scuffs and fixture marks and adherent particles. Also included are localized coating imperfections defined in ISO 9211-1. The line-like imperfections in ISO 9211-1 are regarded as kinds of scratches. The point-like imperfections in ISO 9211-1 are regarded as kinds of digs. Imperfections can be on a surface or within the material. ISO 9802 includes a glossary of terms in use.

Note 2 to entry: Localized surface imperfections in optical assemblies can occur on any optical surface of the assembly. This also includes bubbles and inclusions in a cement layer of the optical subassembly.

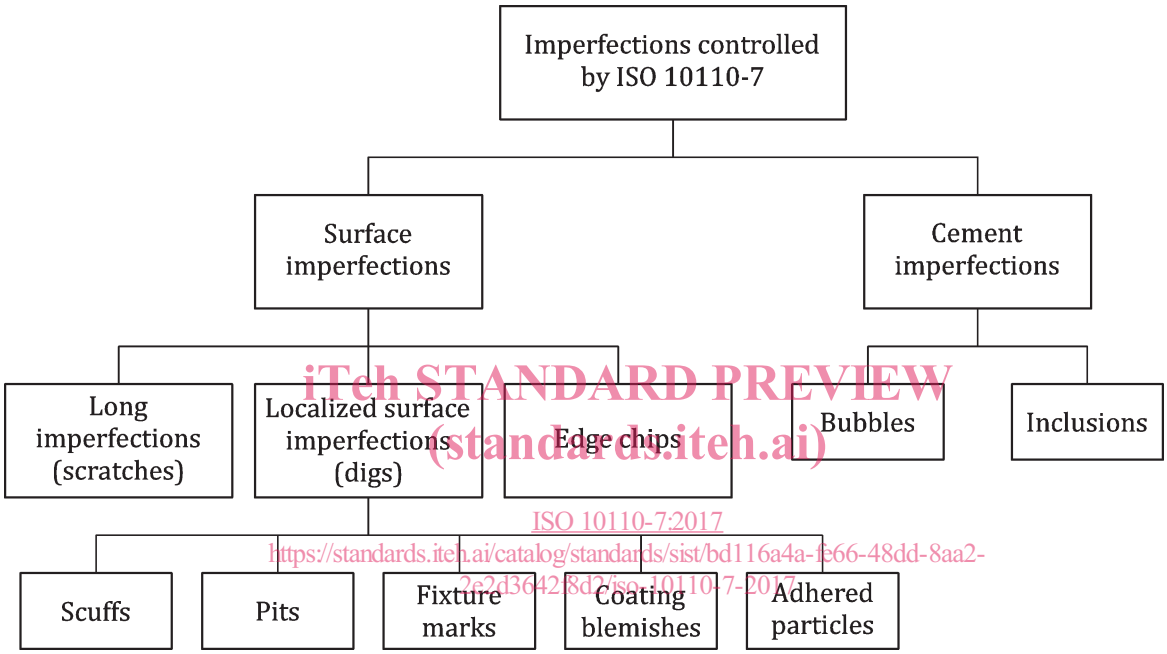

Figure 1 — Classification of imperfections

3.2
long scratch
surface imperfection longer than 2 mm

Note 1 to entry: These imperfections tend to be more visible than shorter imperfections of the same width because of their length.

3.3
edge chip
material entirely removed due to fracture near the periphery of an element

Note 1 to entry: Any separation of material remaining connected to the element is defined as a fracture and is not acceptable.

Note 2 to entry: 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.

3.4
dig
localized surface imperfection which is not a long scratch

3.5
scuff
thin surface imperfection which is shorter than 2 mm

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 on individual optical elements or surfaces is 5/ and the code number for surface imperfections within optical assemblies is 15/.

One or more test regions for surface imperfection specifications may be indicated for an optical surface. If no test regions are indicated, the test region shall be the effective aperture of the surface.

Two different methods of tolerance for imperfections are allowed. The method used is defined by the notation on the drawing. Notations for the specification of the dimensions or size of imperfections are given in 4.2. Notations for the specification of the visibility or appearance of imperfections are given in 4.3.

In ISO 14997, a hierarchy of inspection levels is described. Preference for visual review only (level IV_V or IV_D inspection), a subjective comparison inspection (level IS_D for dimensional specifications or IS_V for visibility specifications) or an objective measurement only (level IM_D for dimensional specifications) may be recorded with a notation as described in 4.2.5 and 4.3.4.

4.2 Dimensional specification method for optical elements and assemblies

4.2.1 Maximum permissible surface imperfections

4.2.1.1 Surface imperfections in the dimensional specification method (general imperfections)

When the dimensional specification method is used, the drawing indication for number and size of surface imperfections that are permissible within the test region of an optical surface is

$$5/N_g \times A_g$$

and for localized surface imperfections in optical assemblies, it is

$$15/N_g \times A_g$$

where

N_g is the number of allowed imperfections;

A_g is the grade number which is equal to the square root of the area of the maximum allowed imperfection, expressed in millimetres as defined in ISO 14997.

Specified grades shall be selected according to the Renard R5 series; acceptable values of grades of surface imperfections are 4; 2,5; 1,6; 1,0; 0,63; 0,4; 0,25; 0,16; 0,1; 0,063; 0,04; 0,025; 0,016 and 0,01. While values greater than 4 or less than 0,01 are allowed, they are not recommended.

In cases where a separate tolerance for long scratches is given, general imperfection tolerances greater than 2 mm should not be used.

In the case of an optical system or subassembly, where the indication 15/ is not used, the surface imperfection tolerances given for the individual elements apply also for the surfaces of the optical system or subassembly, i.e. after cementing (or optically contacting). Imperfection tolerances for

cemented surfaces taken from the element drawings should be adjusted to consider the enlarged or reduced view of the imperfections through an optical element. For example, if an imperfection is to be viewed through a strong negative lens, it will appear to be smaller than it really is. Conversely, if it is to be viewed through a strong positive lens, it will appear to be larger than it really is.

4.2.1.2 Maximum permissible width of imperfections

If necessary, to limit the widths of imperfections, the indication may be supplemented with the indication of the maximum permissible width of the imperfection. By limiting both the area and the width, the length is necessarily constrained as well. In this case, the indication becomes

5/ or $15/N_g \times A_g$; WA_w

where

W is the designation for width;

A_w is the maximum permissible width of any imperfection, expressed in millimetres.

EXAMPLE 5/1 × 0,25; W0,04

In this example, the maximum allowed width of an imperfection is 0,04 mm, while the maximum allowed area of an imperfection is 0,25 mm × 0,25 mm or 0,062 5 mm^2. Thus, the maximum permissible length of a maximum width imperfection is 0,062 5 mm^2 /0,04 mm or 1,6 mm.

4.2.1.3 Coating imperfections

A coating imperfection tolerance may be written after the indication for surface imperfections and separated from it by a semicolon. The indication for coating imperfections that are permissible within the test region of the optical surface or assembly is

C$N_c \times A_c$

where

C is the designation for coating imperfections;

N_c is the number of allowed blemishes of maximum permitted size;

A_c is the grade number as defined in 4.2.1.1.

The imperfection indication including coating imperfections is

$5/N_g \times A_g$; C$N_c \times A_c$

for optical surfaces and

$15/N_g \times A_g$; C$N_c \times A_c$

for optical assemblies.

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

5/ or $15/N_g \times A_g$

4.2.1.4 Long scratches

A tolerance for long scratches (longer than 2 mm) may be written after the indication for surface imperfections (and coating imperfections, if given). The indication for long scratches that are permissible within a test region of an optical surface or assembly is

$$\mathrm{L}N_\mathrm{l} \times A_\mathrm{l}$$

where

L is the indication for long scratches;

N_l is the number of allowed long scratches;

A_l specifies the maximum allowed width of the long scratches, expressed in millimetres.

Specified widths shall be selected according to the Renard R5 series; acceptable values of widths are 0,1; 0,063; 0,04; 0,025; 0,016; and 0,01; 0,006 and 0,004. Widths greater than 0,1 or less than 0,004 are possible, but are not recommended.

Note that this indication for long scratches, L, cannot be combined with a specification of the maximum permissible width, W.

The imperfection indication including coating imperfections and long scratches is

$$5/ \text{ or } 15/N_\mathrm{g} \times A_\mathrm{g};\ \mathrm{C}N_\mathrm{c} \times A_\mathrm{c};\ \mathrm{L}N_\mathrm{l} \times A_\mathrm{l}$$

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

$$5/ \text{ or } 15/N_\mathrm{g} \times A_\mathrm{g}$$

4.2.1.5 Edge chips

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

$$\mathrm{E}A_\mathrm{e}$$

where E is the designation for edge chips and the value A_e specifies the maximum permissible extent of a chip measured from the physical edge of the surface toward the centre 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_e. If no explicit indication for edge chips is given, edge chips are allowed as long as they do not extend into the optical effective area.

In some cases, it can be desirable to evaluate edge chips differently, e.g. as projected onto a plane orthogonal to the optical axis. In these cases, the evaluation criteria should be clarified with a note.

In the case of a protective chamfer, the physical edge is considered to be the outer non-optical surface. In the case of a functional bevel, the physical edge is considered to be the boundary between the bevel and the optical surface.

Edge chip allowances may be applied to a cemented surface in an optical assembly.