



DRAFT INTERNATIONAL STANDARD ISO/DIS 10110-7

ISO/TC 36

Secretariat

TC 172/SC 1
Voting begins on

DIN 10000
Voting terminates on

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION - МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ - ORGANISATION INTERNATIONALE DE NORMALISATION

Optics and optical instruments - Preparation of drawings for optical elements and systems - Part 7: Surface imperfection tolerances

DC-981123007

THIS DOCUMENT IS A DRAFT CIRCULATED FOR COMMENT AND APPROVAL. IT IS THEREFORE SUBJECT TO CHANGE AND MAY NOT BE REFERRED TO AS AN INTERNATIONAL STANDARD UNTIL PUBLISHED AS SUCH.

IN ADDITION TO THEIR EVALUATION AS BEING ACCEPTABLE FOR INDUSTRIAL, TECHNOLOGICAL, COMMERCIAL AND USER PURPOSES, DRAFT INTERNATIONAL STANDARDS MAY ON OCCASION HAVE TO BE CONSIDERED IN THE LIGHT OF THEIR POTENTIAL TO BECOME STANDARDS TO WHICH REFERENCE MAY BE MADE IN NATIONAL REGULATIONS.

International Organization for Standardization

FORM 3 (ISO)

1 Scope

This International Standard applies to the presentation of design and functional requirements for optical elements in technical drawings used for manufacturing and inspection.

- This part gives rules for indicating the level of acceptability of surface imperfections within the effective aperture of the optical surfaces of individual optical elements (scratches, pits, fixture marks, portions of edge chips extending into the effective aperture, coating blemishes, etc.). Also given is the method of indicating the size of allowable edge chips outside the effective aperture.

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

This standard applies to both transmissive and reflecting surfaces. It applies to finished optical elements (including coating) but not to assemblies. Finally, this standard recognizes that allowable surface imperfections may be specified according to either

- Method I - the surface area obscured or affected by the defects,
- or
- Method II - the visibility of the defects.

Rules for indicating allowable surface imperfections are given for both cases.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions in this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

- ISO/DIS 10110 Part 1 Optics and optical instruments - Preparation of drawings for optical elements and systems - Part 1: General
- ISO/DIS 10110 Part 8 Optics and optical instruments - Preparation of drawings for optical elements and systems - Part 8: Surface texture
- ISO/DIS 10110 Part 10 Optics and optical instruments - Preparation of drawings for optical elements and systems - Part 10: Table representing data of a lens element

3 Definitions

Surface imperfections are considered to be localized defects within the polished effective aperture of an optical surface produced by improper treatment during or after the fabrication process. Examples of such surface imperfections are scratches, pits, broken bubbles, streaks, scuffs and fixture marks. Long scratches are defined as thin surface imperfections longer than 2 mm; these tend to be more visible than shorter defects of the same width because of their length. Also included are localized coating blemishes such as grey spots and color sites that absorb or reflect light differently from the bulk of the coating.

Edge chips are localized defects around the periphery of an element. Even if edge chips are outside the optically effective area, they may detrimentally affect the performance of optical systems by disturbing the sealing of elements, being a source of scattered light or being sites of crack propagation.

Long scratches and coating blemishes can only be indicated separately when Method I - Obscured Area - is used.

Not included in this part of the standard are global surface defects such as a lack of a complete polish, "orange peel", waviness or surface roughness (see ISO/DIS 10110 part 8).

4 Indication in drawings

The indication of permissible surface imperfections is given by a code number and a numerical term. The code number for surface imperfections is 5.

The numerical term depends on whether Method I or Method II is used, and is described in subclause 4.1 or 4.2, respectively.

...

...

...

... longer than 2 mm; these tend to be more visible than shorter defects of the same width because of their length. Also included are localized coating blemishes such as grey spots and color sites that absorb or reflect light differently from the bulk of the coating.

...

...

4.1 Method I - Obscured or affected area method

4.1.1 General surface imperfections

According to Method I, the drawing indication for number and size of general surface imperfections, which are permissible within the effective aperture of a surface, is

$$5 / N \times A .$$

The indication in the form $N \times A$ specifies the number, N , of allowed surface imperfections of maximal permitted size, and the grade number, A , which is equal to the square root of the surface area of the maximum allowed defect, expressed in mm. Preferred values for A are given in the first column of Table 1 in Annex 1.

4.1.1.1 Coating blemishes

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

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

$$C N' \times A' ,$$

where the C is the designation for coating blemishes, N' is the number of allowed blemishes of maximal permitted size and A' is the grade number as defined above in 4.1.1.1. The surface imperfection indication including coating blemishes is

the following: $5 / N \times A ; C N' \times A'$.

If no separate indication for coating blemishes is given, it is included in the allowable general surface imperfection indication,

$$5 / N \times A .$$

4.1.1.2 Long scratches

Following the indication for general 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 given by

$$L N'' \times A'' ,$$

- 1) In general, if the surface has an anti-reflection coating, the grade number A'' will be larger than the grade number A for the bare surface imperfections because of the difficulty in distinguishing between small coating blemishes and surface imperfections.

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 mm. The surface imperfection indication including coating blemishes and long scratches is

$$5 / N \times A ; C N' \times A' ; L N'' \times A'' .$$

4.1.1.3 Edge chips

Following the indication for general 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 given by

$$E A''' .$$

where E is the designation for edge chips while the grade number A''' specifies the maximum allowable extent of a chip from the edge of the polished surface of the element, expressed in mm. Any number of edge chips is permissible as long as their extents from the edge do not exceed A''' . The complete surface imperfection indication including coating blemishes, long scratches and edge chips is

$$5 / N \times A ; C N' \times A' ; L N'' \times A'' ; E A''' .$$

4.1.2 Sub-division

A larger number of general 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

$$N \cdot A^2 \quad \text{for general surface imperfections,}$$

$$N' \cdot A'^2 \quad \text{for coating blemishes.}$$

Grade numbers are given in the columns of Table A1 in Annex 1, and the corresponding multiplication factors appear in the first line of the table.

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

When determining the number of permissible surface imperfections, 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 the value $N'' \cdot A''$. In calculating this sum, scratches with widths less than $0,3 A''$ shall not be counted.

4.1.3 Concentrations

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 surface defects is less than 10, then 2 or more surface defects falling within a 5% subarea constitute a concentration.

4.1.4 Scale comparison plate

In Annex 2, a scale comparison plate is described, which may be used as a means for comparing the size of surface imperfections with those of artifacts of known grade numbers. This description has informative character only.

4.2 Method II - Visibility method

This method requires the inspection of the element using an inspection station described in Annex 3.

According to method II an entire optical element is tested. The defects of all optically effective surfaces, as well as material defects (bubbles and other inclusions), are observed simultaneously. Note that this represents a fundamental difference from method I, wherein the surfaces are to be inspected separately.

Although the test does not generally provide a separation of the contributions of the individual surfaces, the surface imperfection tolerances are specified individually, because they provide guidelines for the surface fabrication.

Coating blemishes and long scratches are included as part of the general category of surface imperfections in Method II and thus no special indication is necessary. There is no provision for the treatment of sub-divisions and concentrations, since it is not necessary when applying Method II.

4.2.1 General surface imperfections

The drawing indication for the visibility of surface imperfections of an optical element, as determined by Method II, shall be either

5 / T V

or

5 / R V .

The T or the R in the indication specifies a transmissive or reflective test, respectively, and the V is a visibility class number. (Both "T" and "R" indications are permissible in the case of a dual function surface such as a beamsplitter.) The number V is an integer from 1 to 5 where 1 indicates the most stringent and 5 the weakest requirements on the element with respect to surface imperfections.

4.2.2 Edge chips

Following the indication for surface imperfections by the visibility method (see subclause 4.2.1) and separated from it by a semicolon, the indication for permissible edge chips is given the same as in Method I as

E A"

where E is the designation for edge chips while the grade number A" specifies the maximum allowable extent of a chip from the edge of the polished surface of the element, expressed in mm. Any number of edge chips is permissible as long as their extents from the edge do not exceed A". The complete surface imperfection indication including edge chips for Method II is

5 / T N ; E A" or 5 / R N ; E A" .

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. Preferably, it is to be associated with the other indications of surface tolerances (surface form tolerance and centring tolerance). An example of such an indication is given in the annex to ISO/DIS 10110 part 1.

Alternatively, the indication may be given in a table according to ISO/DIS 10110 part 10.

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 ISO/DIS 10110 part 1: General, sub-clause 4.8.3.

ANNEXES :

Annexes concerning Method I

- 1 Table of preferred values of grade numbers
- 2 Scale comparison plate

Annexes concerning Method II

- 3 Description of inspection station
- 4 Tables of visibility class designations
- 5 Standard defect for calibration

General Annexes

- 6 Examples
- 7 Informative reference material

ANNEX 1

Preferred values of grade numbers and sub-division factors for Method I

The information given in this annex is essential to the standard.

The preferred range of values for grade number A is given in the first column of Table A1.1. Column two through four show the connection between grade numbers and their multiplication factors.

The table indicates, for example, that six surface imperfections of grade number 0,25 have the same area as one imperfection of grade number 0,63.

Table A1.1 Preferred size designation and factors for sub-division for surface imperfections according to Method I

	Multiplication factors			
	1	2,5	6,3	16
Grade numbers [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 $1/2 \times 0,25$, then $2 \cdot 2,5 = 5$ surface imperfections of grade number 0,16, or $2 \cdot 6,3 = 12$ surface imperfections of grade number 0,1 or $2 \cdot 16 = 32$ surface imperfections of grade number 0,063 are permissible. Alternatively, any corresponding combination of the above is permissible, provided that the total projected area of all surface imperfections with a grade number greater than $0,16 \cdot 0,25 = 0,04$ does not exceed $2 \cdot 0,25^2 \text{ mm}^2 = 0,125 \text{ mm}^2$.

ANNEX 2

Recommended dimensions of artifacts on a scale comparison plate for Method I

The information given in this annex is informative only.

This annex gives recommended dimensions for circular and scratch-like artifacts, which may be used as a means for size comparison during inspection of optical elements.

For the size comparison of defects on transmissive surfaces artifacts consisting of non-transmitting material on glass are useful.

For the size comparison of defects on reflection surfaces, non reflecting artifacts on a surface which is otherwise reflecting may be useful.

In both cases it is recommended, that the scale comparison plates be made by depositing chrome onto glass by evaporation.

Larger or smaller artifacts may also be useful for certain applications.

Table A2.1 Recommended dimensions of artifacts for size comparison

	Grade number in μm	Diameter of circular "defect" in μm	Dimension of "Scratch" in $\mu\text{m} \times \mu\text{m}$
plate #1	.004	4,5	1 x 16
	.006	7	1,6 x 25
	.010	11	2,5 x 40
	.016	18	4,0 x 63
	.025	28	6,3 x 100
	.040	45	10 x 160
plate #2	.040	45	10 x 160
	.060	70	16 x 225
	.100	110	25 x 400
	.160	180	40 x 630
	.250	280	63 x 1000
	.400	450	100 x 1600

ANNEX 3

Description of inspection station for Method II

The information given in this annex is essential for the application of Method II

A3.1 Principle of operation

Light scattered from the surface imperfections of the sample under test is compared with a reference background illumination. The visibility class is determined by the level of sample illumination, at which surface defects become visible; each visibility class corresponds to a particular sample illumination.

In order to guarantee a uniform level of sensitivity, independent of the observer, the reference background illumination shall be adjusted, using a standard sample described in Annex 5.

Detailed descriptions of the principle of operation regarding physics and psychological optics are given in Annex 7, References [1] through [3].

A3.2 Description of the inspection station

The inspection station for the classification of surface defects includes two paths:

- a path incorporating a uniform hemispherical illumination of the sample, excluding the solid angle determined by the eye location of an observer, located at 30 cm from the sample. (This means that, in the absence of a sample, no light of the illumination reaches the observer's eyes.)
- a reference path which superposes a background of uniform luminance in the observer's field of view by means of a beam splitter. This luminance shall be adjusted until the standard defect described in Annex 5, when illuminated at a level of 2500 Lux, is just visible to the observer. (It is to be noted that each observer must adjust the inspection station in this manner.)

A3.3 Schematic diagram of the station

Figures A3.1 and A3.2 show schematic diagrams of an inspection station for transmissive and reflective tests, respectively. By appropriate arrangement of optical fibers, dark-field illumination of the sample under test is achieved. (Further information is given in Annex 7, Reference [3].)

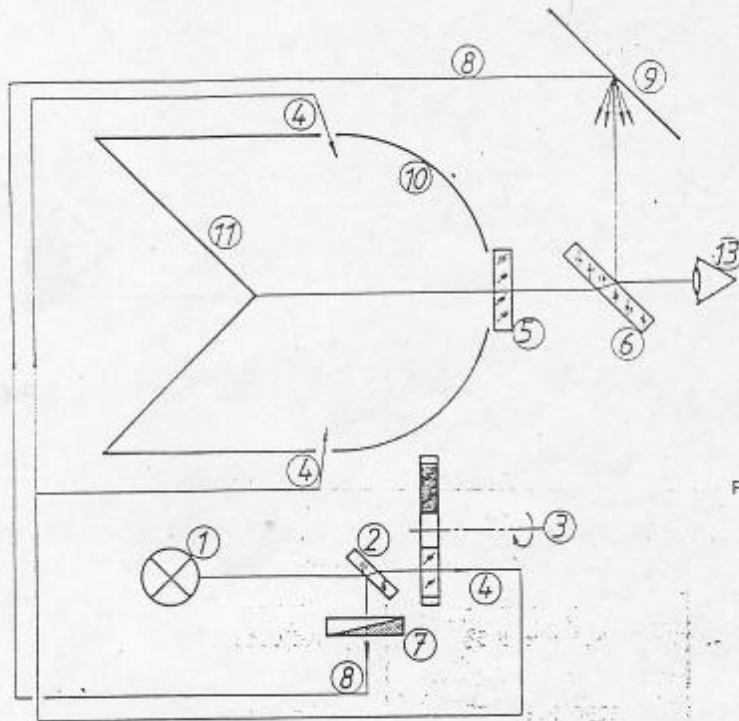


Figure A3.1 Schematic diagram of inspection station for transmissive test

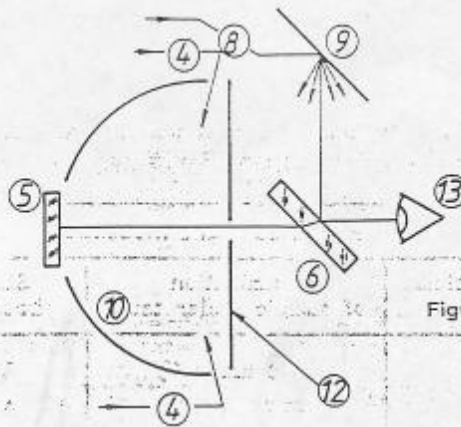


Figure A3.2 Schematic diagram of inspection station for reflective test (illumination etc.: see fig. A3.1)

Explanation of Figures A3.1 and A3.2:

- | | |
|--|--|
| 1 Light source (xenon arc lamp) | 7 Background illumination adjustment |
| 2 Beam splitter | 8 Background illumination channel (fiber optics) |
| 3 Selector for sample illumination grade | 9 Grey background |
| 4 Sample illumination channel (fiber optics) | 10 Hemisphere, inner surface matte white |
| 5 Sample under test | 11 Light trap (black) |
| 6 Beam splitter | 12 Baffle (black) |
| | 13 Observer's Eye |

ANNEX 4

Tables of visibility class designations for Method II

The information given in this annex is normative in nature.

Table A4.1 Visibility class designations for transmitted light inspection

Transmitted Light Inspection		
Visibility class	Illumination of sample under test	Standard background
T 5	310 lux \pm 5%	Adjusted
T 4	625 lux \pm 5%	Adjusted
T 3	1250 lux \pm 5%	Adjusted
T 2	2500 lux \pm 5%	Adjusted
T 1	2500 lux \pm 5%	Black

Table A4.2 Visibility class designations for reflected light inspection

Reflected Light Inspection		
Visibility class	Illumination of sample under test	Standard background
R 5	310 lux \pm 5%	Adjusted
R 4	625 lux \pm 5%	Adjusted
R 3	1250 lux \pm 5%	Adjusted
R 2	2500 lux \pm 5%	Adjusted
R 1	2500 lux \pm 5%	Black

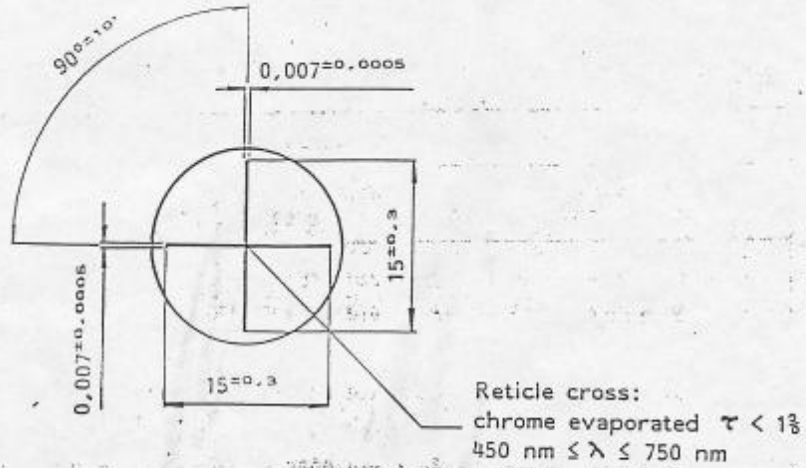
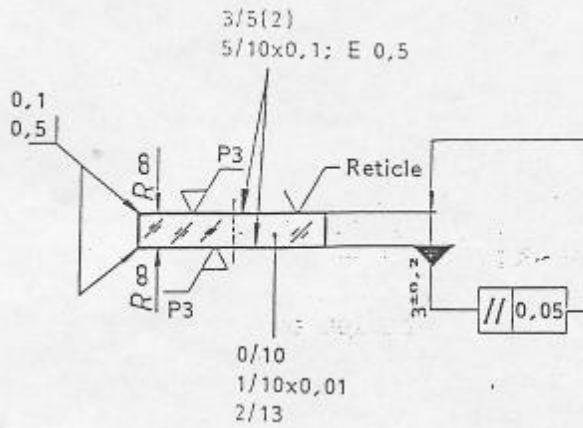
Remarks concerning quality grades:

1. Although the illumination for different classes is defined within $\pm 5\%$, the illumination ratio between these classes should be within $\pm 2\%$.
2. For parts intended to be inspected before coating, care should be taken of eventual contrast increase due to coating.
3. Unless otherwise specified, any defect visible by the method described here is taken into account, without distinction between material and surface defects.

ANNEX 5

Standard defect for calibration of inspection station for Method II

The information of this annex is normative in nature.



Material: Class, NATO 517 642

ANNEX 6

Examples of indications for permissible surface imperfections

The information given in this annex is informative in nature.

Example 1 (Method 1)

Three surface imperfections of grade size $A = 0,63$, 2 coating blemishes of grade size $A' = 1,6$, 2 long scratches of grade size $A'' = 0,01$ and edge chips of a depth of $A''' = 1,0$ are allowed. The size grade $A = 0,63$ is equivalent to an area of $(0,63)^2 = 0,40 \text{ mm}^2$ per defect.

5/3x0,63;C 2x1,6;L 2x0,01;E 1,0	Example indication for surface imperfections using Method 1
5/ 3 0,63	Numerical symbol for surface imperfections Number of allowed imperfections Size grade number for surface imperfections
C 2 1,6	Symbol for coating blemishes Number of allowed coating blemishes Size grade number for coating blemishes
L 2 0,01	Symbol for long scratches Number of allowed long scratches Size grade number for long scratches
E 1,0	Symbol for edge chips Size grade number for depth of edge chips

The size grade number allows the 3 allowable surface imperfections to be sub-divided into multiple smaller imperfections, provided that the sum of the areas of the sub-divided defects does not exceed $3 \cdot (0,63)^2 = 1,2 \text{ mm}^2$, and that no single defect exceeds the size grade number, 0,63. Referring to Annex 1, it is seen that, for example, the following set of surface imperfections would be allowed:

- 1 imperfection of size grade 0,63
 - + 2 imperfection of size grade 0,40
 - + 6 imperfection of size grade 0,25
- with a total area of $< 1,2 \text{ mm}^2$.

Imperfections with a grade number of $0,16 \cdot 0,63 = 0,10$ or smaller shall not be counted.

Example 2 (Method II)

A lens element shall have no visible imperfections when viewed in transmission in the Visibility Test Apparatus (referenced in Annex 3), when the illumination corresponds to visibility class 3 (see Annex 4). In addition, no edge chips are permitted that extend more than 1,0 mm beyond the edge of the element.

5/T3; E 1,0	Example indication for surface imperfections, using Method II
5/	Numerical symbol for surface imperfections
T	Symbol indicating the transmission visibility method
3	Integer indicating the imperfection visibility level
E	Symbol indicating edge chips
1,0	Size grade number for depth of edge chips