11. Specification using ISO 10110

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Outline

- Bit of standards history
- Types of standards
- Classes of relevant ISO standards
- ISO 10110 Optical drawing standard

Standards history

- IEC - early international standards organization
- ISO started after WW2 as part of UN charter
  - Headquarters in Geneva
  - All national member bodies are governmental except
    - The US which is private – ANSI
    - NIST is not the US member body of ISO
- ISO has standards in all fields except electrical
  - These are the purview of IEC
  - Work in each field carried out by Technical Committees
  - TC's are sponsored by national standards bodies

Types of standards

- Terms and definitions – helps with communication
- Performance standards – how well something works
- Test methods – verify the performance standards
- Horizontal standards – apply to all documents in a field
  - Terms and definitions are horizontal standards
- Vertical standards – apply to a specific discipline
  - Performance and test methods

Features of ISO standards

- Standards are numbered chronologically
  - But reviewed and updated every five years – mandatory
- Official languages: English, French and Russian
  - *De facto* language is English
- Standards use SI units exclusively
  - Use symbols where possible for universal understanding
- Build on previous national and ISO standards
- Use preferred quantities
- Incorporate default tolerances

Relevant classes of ISO standards

- ISO 9000 – Quality management and quality assurance standards
- ISO TC172 Optics and optical instruments
  - TC is run by DIN – German standards org.
  - SC's run by DIN, AFNOR, GOST, Japan
  - WG's have members from US, UK, France, Germany, Switzerland, Russia, China and Japan

Scope of ISO TC172

"Standardization of terminology, requirements, interfaces and test methods in the field of optics and photonics. This includes complete systems, devices, instruments, ophthalmic optics, optical and photonic components, auxiliary devices and accessories, as well as materials.

Optics and photonics are used in the meaning of generation, handling and detection of optical radiation including signal processing.

Excluded: standardization for specific items in the field of cinematography (ISO/TC 36), photography (ISO/TC 42), eye protectors (ISO/TC 94), micrographics (ISO/TC 171), fibre optics for telecommunication (IEC/TC 86) and electrical safety of optical elements, and general lighting."

Sub-Committees in TC172

ISO TC172 Optics and photonics

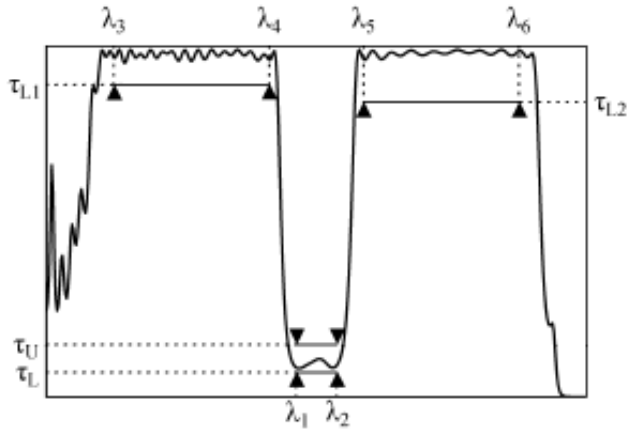
ISO TC172 SC01 Fundamental standards - DIN
ISO TC172 SC03 Optical materials and components - AFNOR
ISO TC172 SC04 Telescopic systems - GOST
ISO TC172 SC05 Microscopes and endoscopes
ISO TC172 SC06 Surveying instruments
ISO TC172 SC07 Ophthalmic optics and instruments - DIN
ISO TC172 SC09 Electro-optical systems – Japan

ISO 9211 Optical coatings – written by SC 3
ISO 10110 Optical drawings – written by SC 1

ISO 9211 Optical coatings

- 4 part standard includes
  - Terms and definitions
  - Coating spectral properties
  - Durability and cosmetic appearance
  - Test procedures to verify performance
- Much more thorough and comprehensive that the US MIL coating specs

Example from ISO 9211



General designation:

FI-BR $\tau_L < \tau(\lambda_1 \text{ to } \lambda_2, \theta) < \tau_U$

$\tau_{Li} < \tau(\lambda_{2i+1} \text{ to } \lambda_{2i+2}, \theta) \ldots;\ i = 1, 2, \ldots$

Numerical example:

FI-BR $0{,}05 < \tau$ (535 nm to 565 nm) $< 0{,}15$

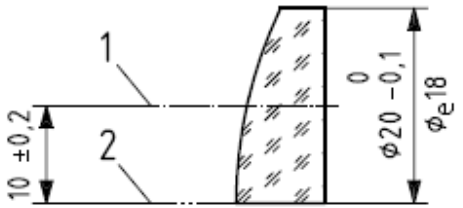
τ (400 nm to 515 nm) $> 0{,}90$

τ (585 nm to 700 nm) $> 0{,}85$

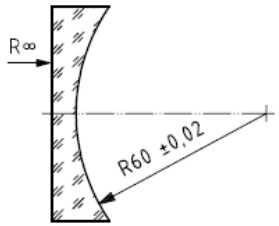
ISO 10110 Optical drawings

- ISO 10110-1 General
- ISO 10110-2 Stress birefringence
- ISO 10110-3 Bubles and inclusions
- ISO 10110-4 Material imperfections
- ISO 10110-5 Surface form errors
- ISO 10110-7 Surface imperfections
- ISO 10110-8 Texture
- ISO 10110-9 Surface treatment and coatings
- ISO 10110-10 Table of data for optical elements
- ISO 10110-11 Non-toleranced data
- ISO 10110-12 Aspheric surfaces
- ISO 10110-14 Wavefront deformation
- ISO 10110-17-Indications for laser damage threshold

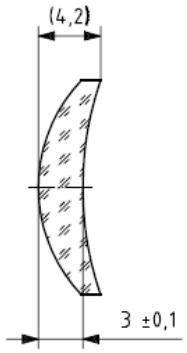
General – Requirements peculiar to optical drawings



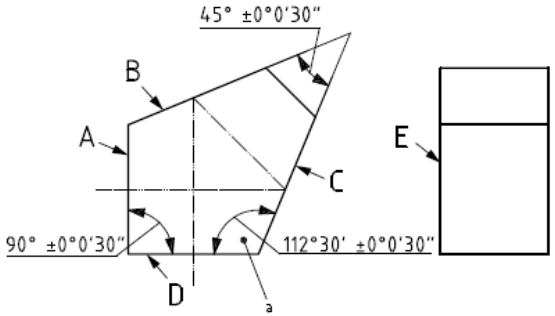
Line types to indicate axis types



Radius indication



Cneter thickness indication



∡ A, E = 90° ± 0° 10'
∡ D, E = 90° ± 0° 10'
∡ B, E = 90° ± 0° 3'
∡ C, E = 90° ± 0° 3'
[a] Mark for identification.

Indication of angles

Overview of ISO 10110

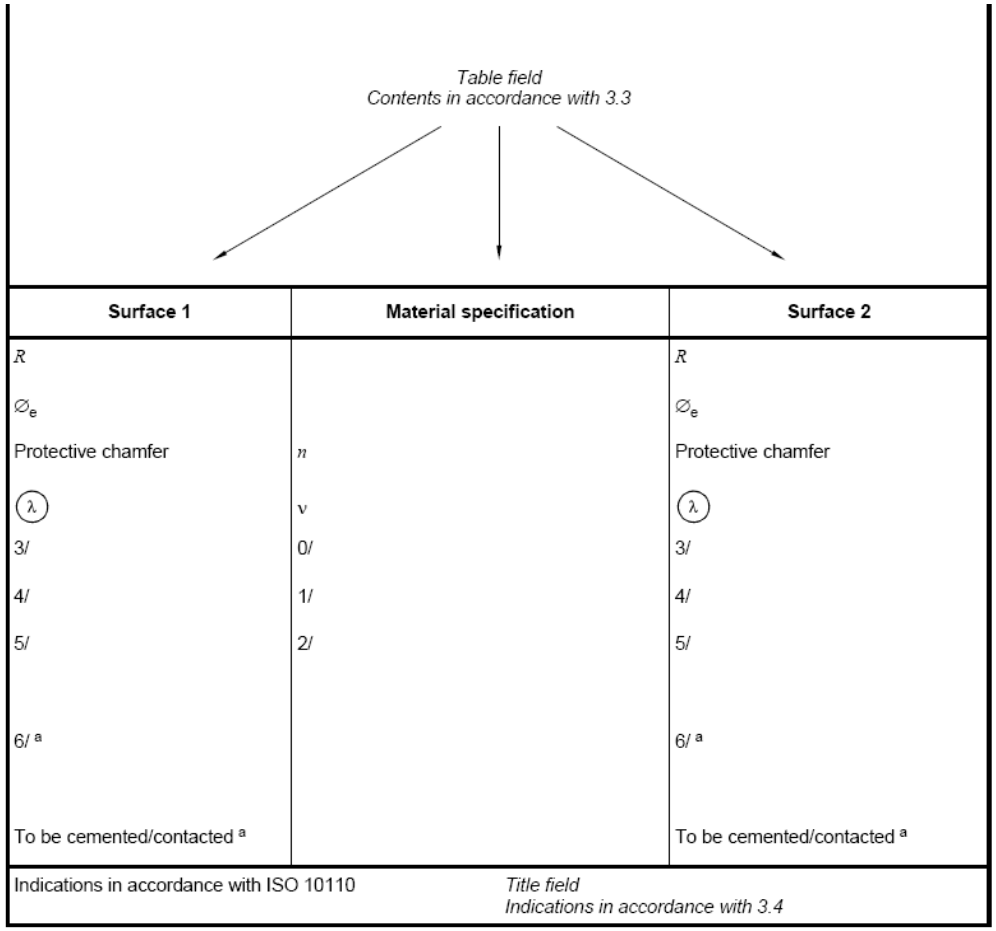


Table field
Contents in accordance with 3.3

Surface 1	Material specification	Surface 2
R		R
$\varnothing_e$		$\varnothing_e$
Protective chamfer	n	Protective chamfer
(λ)	ν	(λ)
3/	0/	3/
4/	1/	4/
5/	2/	5/
6/ [a]		6/ [a]
To be cemented/contacted [a]		To be cemented/contacted [a]

Indications in accordance with ISO 10110

Title field
Indications in accordance with 3.4

[a] ... If required, delete non-applicable data.

0/ Stress birefringence

1/ Bubbles and inclusions

2/ Striae and inhomogeneity

3/ Figure errors

4/ Centering

5/ Finish – scratch/dig

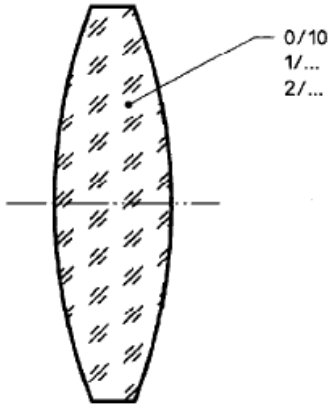
6/ Texture - roughness

Indication 0/ Stress birefringence

Indication is “0/A” where A is the maximum allowable stress in nm/cm of optical path length in the sample

Table A.1 — Examples of birefringence tolerances and typical applications

Permissible optical path difference (OPD) per cm glass path	Typical applications
< 2 nm/cm	Polarisation instruments Interference instruments
5 nm/cm	Precision optics Astronomical optics
10 nm/cm	Photographic optics Microscope optics
20 nm/cm	Magnifying glasses View finder optics
Without requirement	Illumination optics



1/NxA Bubbles and inclusions

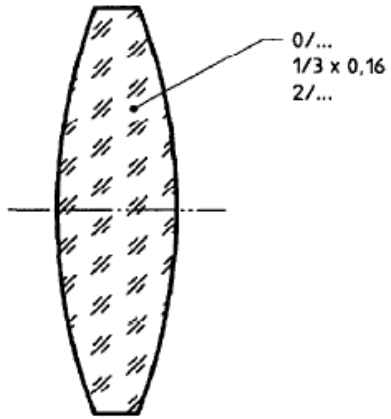
N is the number of bubbles or inclusions in the optical element

A is the length of the side of a square in mm

The total area obscured by inclusions is thus N x A^2

Since it is an area based designation, the bubbles can be sub-divided, that is, a bubble of area A^2 can be divided into 2.5 bubbles whose side is .63A or 6.3 bubbles whose side is .4A

There is a table of preferred bubble sizes that shows the sub-divisions



2/ Striae and inhomogeneity

Inhomogeneity is a gradual variation of index within an element

Striae are inhomogeneities having a small spatial extent

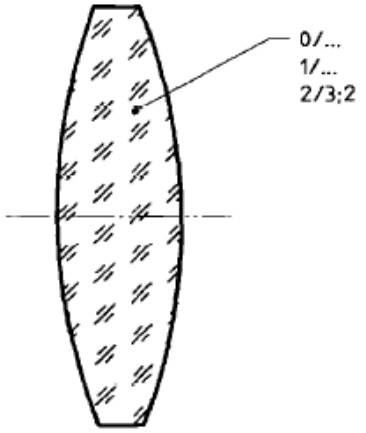
Both designations are in terms of a class

Table 1 — Inhomogeneity classes

Class	Maximum permissible variation of refractive index within a part 10^{-6}
0	± 50
1	± 20
2	± 5
3	± 2
4	± 1
5	± 0,5

Table 2 — Classes of striae

Class	Density of striae causing an optical path difference of at least 30 nm in %
1	⩽ 10
2	⩽ 5
3	⩽ 2
4	⩽ 1
5	Extremely free of striae Restriction to striae exceeding 30 nm does not apply Further information to be supplied in a note to the drawing



3/ Figure or surface form error

The indication has three forms:

3/A(B/C); λ = E	The E may be dropped if the wavelength being used is 546 nm,
3/A(B/C) RMSx < D; λ = E	The ”standard” wavelength
3/—RMSx < D; λ = E	The x may be t, i or a

A is the power difference from a test plate in fringe spacings (fringes)

B is the irregularity in fringe spacings

C is the rotationally symmetric irregularity in fringe spacings

RMSt means total departure from a reference spherical surface

RMSi means only the irregularity departure from a reference surface

RMSa means the irregularity after all rotationally symmetric error is removed

4/ Centering

The indication for centering will have one of three forms:

$4/\sigma$

or

$4/\sigma(L)$

or

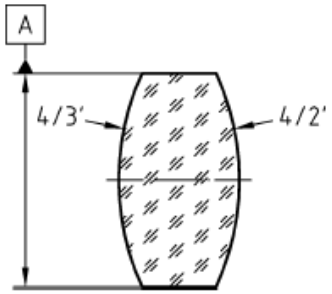
$4/\Delta\tau$

Where σ is the angle between the axis and the surface

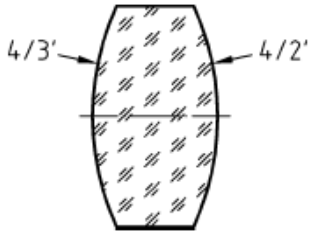
And L is the maximum lateral displacement in mm

And τ is the angle of any cement layer

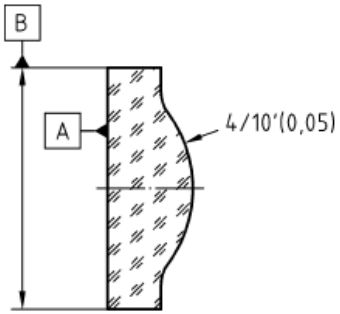
The angles are given in minutes or seconds of arc



a) Explicit indication

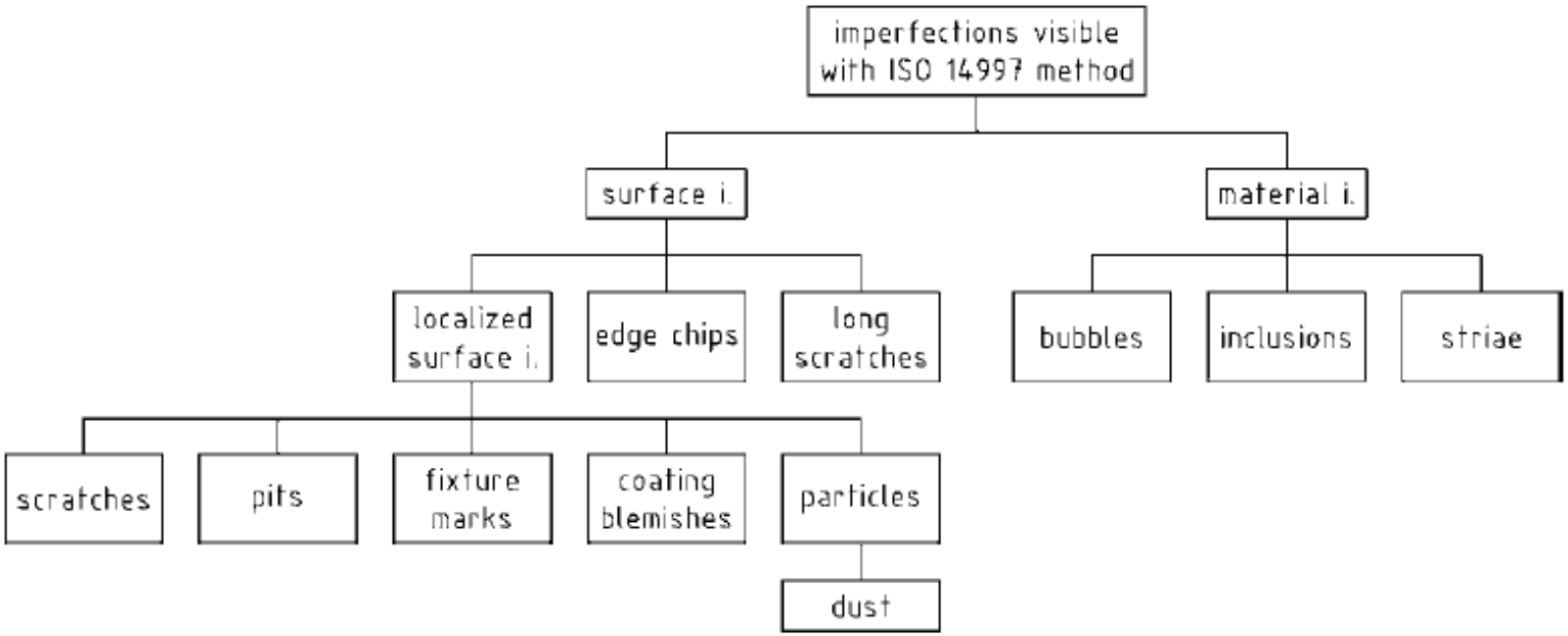


b) Abbreviated indication



Aspheric surface

5/ Surface imperfections



Classification of all possible imperfections

This indication is only for localized, edge chips, long scratches and the coating imperfections listed below the localized

Follows same area scheme as for material imperfections, bubbles

5/ Surface imperfections

Surface imperfections are localized defects such as scratches or digs

5 or 15/ *N* x *A*; C*N'* x *A'*; L*N''* x *A''*; E*A'''*

Where for summarization

5/ represents surface imperfections and 15/ represents surface imperfections in assemblies, respectively;

N x *A* for surface imperfections;

C*N'* x *A'* for coating blemishes ;

L*N''* x *A''* for long scratches;

and E*A'''* for edge chips

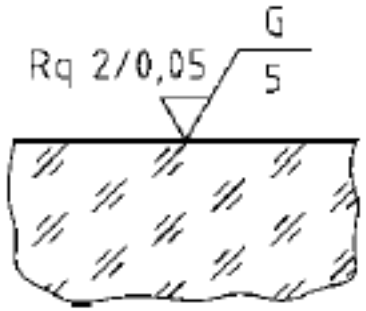
A and A' are the sides of a square as in 1/

A" is the width of long scratches

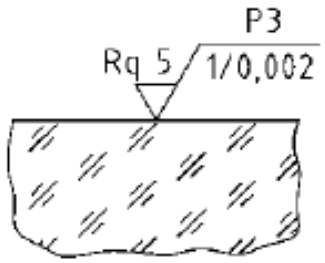
A"' is the maximum extent inward of the chip

Texture

Texture is a property of the entire surface such as finish



Indication for a ground surface with an rms roughness between .05 and 2 μm with a sampling length of 5 mm



Indication for a polished surface with an rms finish of 5 nm over a spatial bandwidth of .002 to 1 mm

The P means polished and the 3 relates to residual pits

Note units change between ground and polished

Surface treatment and coatings

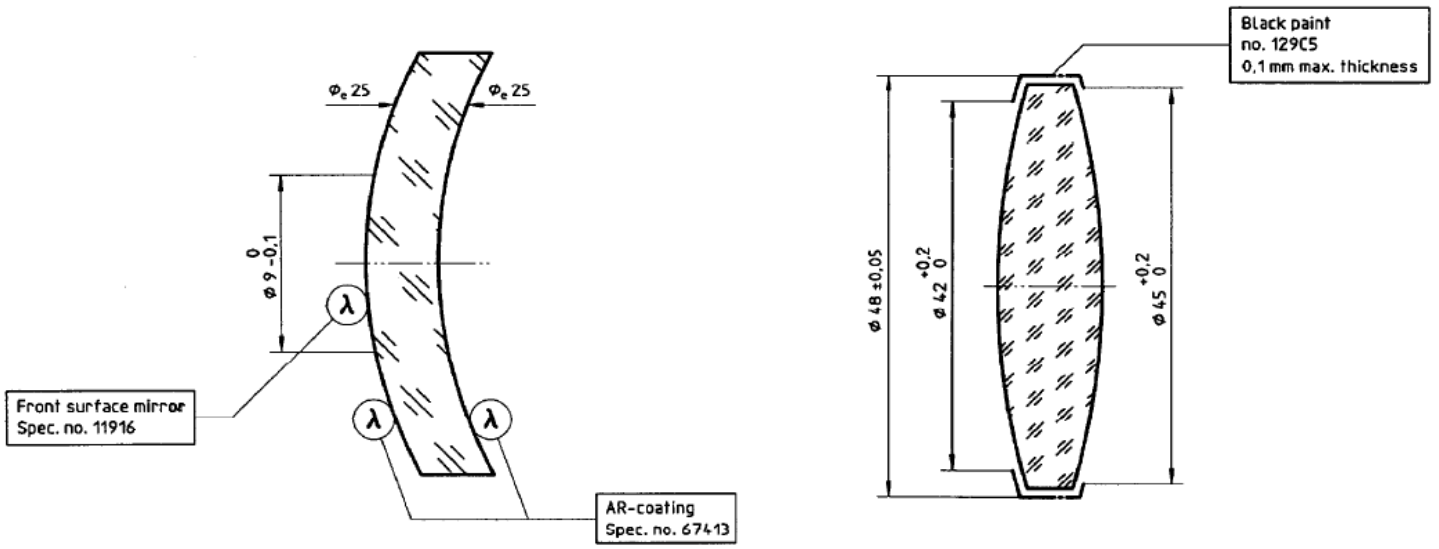
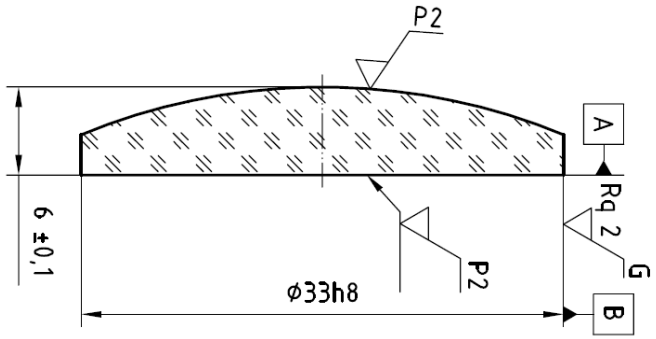


Table of data for an optical element

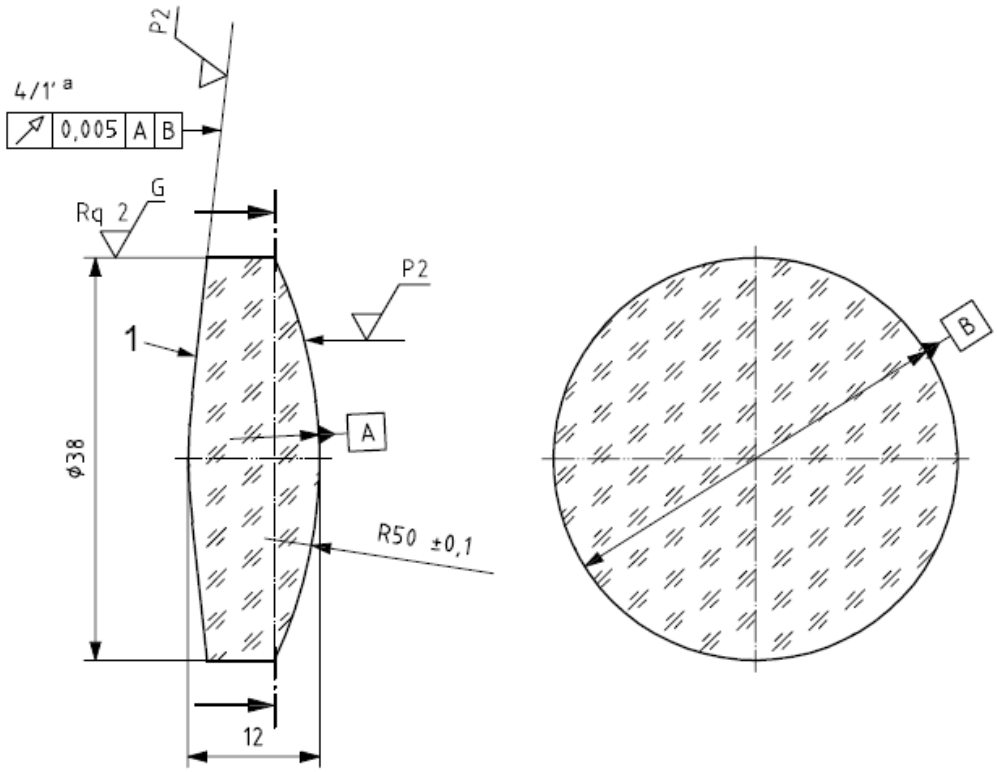


Surface 1	Material specification	Surface 2
R 37,449 CX	Hoya LaC9 or Schott N-LaK9	R ∞
$\varnothing_e$ 30,5		$\varnothing_e$ 29
Protective chamfer 0,4 to 0,6	n (1 060 nm) 1,675 9 ± 0,001	Protective chamfer 0,4 to 0,6
(λ) AR 209.1060	ν —	(λ) AR 209.1060
3/ 5 (1)	0/ 20	3/ 5(1)
4/ 1,4′	1/ 5 × 0,1	4/ —
5/ 5 × 0,1; C 5 × 0,16; L 3 × 0,004; E 0,4	2/ 1; 2	5/ 5 × 0,1; C 5 × 0,16; L 3 × 0,004; E 0,4
6/ —		6/ —
Indications in accordance with ISO 10110		Lens 114.379

Defaults for non-toleranced features

Property	Range of maximum (diagonal) dimension of the part mm			
	up to 10	over 10 up to 30	over 30 up to 100	over 100 up to 300
Edge length, diameter (mm)	± 0,2	± 0,5	± 1	± 1,5
Thickness (mm)	± 0,1	± 0,2	± 0,4	± 0,8
Angle deviation of prisms and plate	± 0° 30′	± 0° 30′	± 0° 30′	± 0° 30′
Width of protective chamfer (mm)	0,1 to 0,3	0,2 to 0,5	0,3 to 0,8	0,5 to 1,6
Stress birefringence in accordance with ISO 10110-2 (nm/cm)	0/20	0/20	—	—
Bubbles and inclusions in accordance with ISO 10110-3	1/3 × 0,16	1/5 × 0,25	1/5 × 0,4	1/5 × 0,63
Inhomogeneity and striae in accordance with ISO 10110-4	2/1;1	2/1;1	—	—
Surface form tolerances in accordance with ISO 10110-5	3/5(1)	3/10(2)	3/10(2) (all ø 30)	3/10(2) (all ø 60)
Centring tolerances in accordance with ISO 10110-6	4/30′	4/20′	4/10′	4/10′
Surface imperfection tolerances in accordance with ISO 10110-7	5/3 × 0,16	5/5 × 0,25	5/5 × 0,4	5/5 × 0,63

Aspheric surfaces

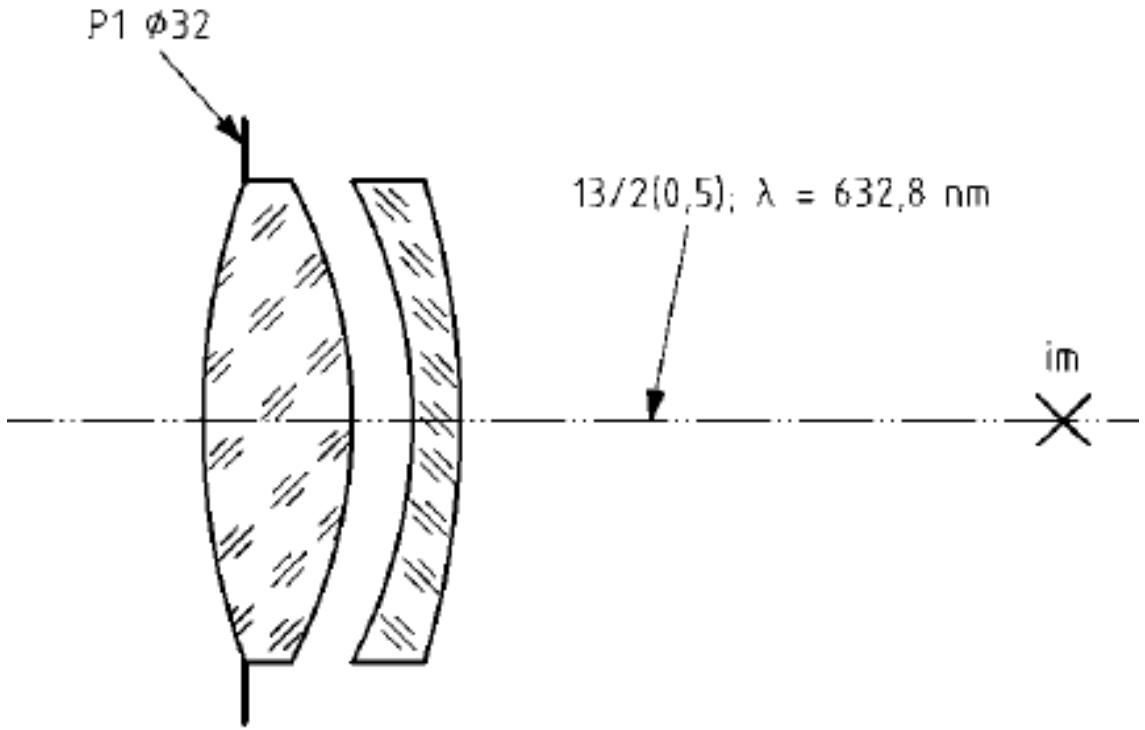


Key

1 asphere

$$z = \frac{h^2}{R\left(1+\sqrt{1-(1+\kappa)h^2/R^2}\right)} + \sum_{i=2}^{5}\left(A_{2i}h^{2i}\right)$$

Wavefront deformation



Details of indication similar to 3/ for figure error

6/ Laser damage threshold

6/25 J-cm^{-2} ; 1064 nm; 20 ns means threshold is above an energy density of 25 J-cm^2 at a wavelength of 1064 nm for 20 ns pulses

6/10 kW-cm^{-1} ; 10.6 μm; 1 s means threshold is above a linear power density of 10 kW/cm at a wavelength of 10.6 μm for an exposure time of 1 second

The indication is attached to the surface via the same leader as used for other surface properties.

Other ISO optical standards

ISO 11421 Accuracy of OTF measurements
ISO 11455 Determination of birefringence
ISO 12123 Specification of raw optical glass
ISO 13653 Measurement of relative irradiance in the image plane
ISO 14999 - 4 Interpretation figure errors
ISO 15368 Measurement of reflectance and transmittance of plane objects
ISO 15529 Measurement of MTF of sampled imaging systems
ISO 15795 Image degradation due to chromatic aberrations
ISO 21254-1 Laser damage thresholds
ISO 21254-2 Laser damage thresholds