प्रकाशिकी और फोटोनिक्स — प्रकाशीय तत्वों और प्रणालियों के लिए आरेखण तैयार करना

भाग 1 सामान्य

(*पहला पुनरीक्षण*)

Optics and Photonics — Preparation of Drawings for Optical Elements and Systems

Part 1 General

(*First Revision*)

ICS 01.100.20; 37.020

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Optics and Photonics Sectional Committee, PGD 39

NATIONAL FOREWORD

This Indian Standard (Part 1) (First Revision) which is identical to ISO 10110-1: 2019 'Optics and photonics — Preparation of drawings for optical elements and systems — Part 1: General' issued by the International Organization for Standardization (ISO) was adopted by the Bureau of Indian Standards on the recommendation of the Optics and Photonics Sectional Committee and after approval of the Production and General Engineering Division Council.

This standard specifies drawing indication for optical elements and systems. It also specifies the presentation in drawings of the characteristics, including the tolerances of optical elements and systems.

This standard was first published in 1970. This revision supersedes the originally published IS 5920 : 1970 'Recommendations for the preparation of drawings for optical elements and systems'.

This standard has been published in thirteen parts. The other parts in this series are:

Part 2   Surface form tolerances

Part 3   Centring tolerances

Part 4   Surface imperfections

Part 5   Surface texture

Part 6   Surface treatment and coating

Part 7   Non-toleranced data

Part 8   Aspheric surfaces

Part 9   Wavefront deformation tolerance

Part 10   Diffractive surfaces

Part 11   Laser irradiation damage threshold

Part 12   Stress birefringence, bubbles and inclusions, homogeneity, and striae

Part 13   General description of surfaces and components

The text of ISO standard has been approved as suitable for publication as an Indian Standard without deviations. Certain conventions are, however, not identical to those used in Indian Standards. Attention is particularly drawn to the following:

   a)   Wherever the words 'International Standard' appear referring to this standard, they should be read as 'Indian Standard'; and

   b)   Comma (,) has been used as a decimal marker while in Indian Standards, the current-practice is to use a point (.) as the decimal marker.

Contents

Indian Standard

OPTICS AND PHOTONICS — PREPARATION OF DRAWINGS FOR OPTICAL ELEMENTS AND SYSTEMS

Part 1 General

(First Revision)

1 Scope

This document specifies the general layout of drawings and provides examples of indications in the ISO 10110 series, which standardizes drawing indications for optical elements and systems.

This document specifies the presentation in drawings of the characteristics, including the tolerances, of optical elements and systems. This document also includes the popular tabular format, formerly presented in ISO 10110-10. This tabular format, now described in 5.1, is the preferred format for ISO 10110 drawings.

Rules for preparation of technical drawings as well as for dimensioning and tolerancing are given in various ISO Standards. These general standards apply to optical elements and systems only if the necessary rules are not given in the various parts of ISO 10110.

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 128-24, *Technical drawings — General principles of presentation — Part 24: Lines on mechanical engineering drawings*

ISO 10110-6, *Optics and photonics — Preparation of drawings for optical elements and systems — Part 6: Centring tolerances*

ISO 10110-11, *Optics and photonics — Preparation of drawings for optical elements and systems — Part 11: Non-toleranced data*

ISO 10110-12, *Optics and photonics — Preparation of drawings for optical elements and systems — Part 12: Aspheric surfaces*

ISO 10110-18, *Optics and photonics — Preparation of drawings for optical elements and systems — Part 18: Stress birefringence, bubbles and inclusions, homogeneity, and striae*

ISO 10110-19, *Optics and photonics — Preparation of drawings for optical elements and systems — Part 19: General description of surfaces and components*

ISO 12123, *Optics and photonics — Specification of raw optical glass*

ISO 80000-1, *Quantities and units — Part 1: General*

3 Terms and definitions

No terms and definitions are listed in this document.

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

4 Fundamental stipulations

All indications in drawings for optical elements and systems shall apply to the finished optical component or assembly, i.e., to its final form as described on the drawing, except where other parts of ISO 10110 stipulate otherwise or if explicitly stated on the drawing.

Whenever details or symbols specified in this document are found to be inadequate to clearly define the requirement, the information should be supplemented by a note or special instruction (see 5.1.2).

All linear dimensions are in millimetres, unless otherwise stated.

All units shall be shown using either a decimal comma or a decimal point, in accordance with ISO 80000-1. One or the other format should be used; the two conventions shall not be mixed on one drawing. Delimiters for the thousands place shall never be used, regardless of the decimal format.

All optical and dimensional data refer to the reference temperature of 20 °C[1], unless specified otherwise.

Unless specified elsewhere, the omission of a permissible deviation or material imperfection from the drawing shall indicate that the provisions of ISO 10110-11 apply. By definition none of the GPS defaults, including the decision rules, apply unless specifically invoked in ISO 10110.

Surface form and transmitted wavefront deviation shall be specified in units of nanometers or, if preferred, micrometers or fringe spacings. Because of the existence of older (national) standards for optical drawings, a possibility of incorrect interpretation of data exists. For this reason, a reference to ISO 10110 shall appear on each drawing. In addition, as described in ISO 7944, wavelengths other than e-line or d-line may be used as the reference wavelength. Therefore if waves or fringe spacings are used, the reference wavelength shall always be indicated[2]. For example:

"Indications in accordance with ISO 10110; λ = 546,07 nm"

or

"Ind. acc. ISO 10110; λ = 632,8 nm".

These indications should preferably be together and associated with the title field of the drawing (see Annex A as well as Figures 1 and 2).

While it is preferred to only use one wavelength in an optical element drawing, the usage of other wavelengths is permitted, e.g. a reference wavelength of 546,07 nm but indicating a different wavelength for refractive index and Abbe number (n_e, v_d, etc.). In those cases, the different wavelength strictly applies only to the property indicated with the different wavelength. Any other value not separately indicated shall be considered using the reference wavelength.

NOTE   For legacy drawings created prior to the publication of this revision, the default wavelength was 546,07 nm.

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[1]   20 °C is the reference temperature in accordance with ISO 1. In the 1996 edition of ISO 10110-1, the default value for the reference temperature was 22 °C.

[2]   In earlier editions of ISO 10110-1, the default value for the reference wave length was 546,07 nm.

5 Presentation and dimensioning

5.1 Drawing format

5.1.1 General

The preferred layout of a drawing of optical elements or subassemblies is the tabular format. It was originally described in ISO 10110-10, but has been incorporated here for ease of use. All of the rules regarding line type, notation and symbology given below apply to drawings in a tabular format, unless they are explicitly contradicted by this part of the standard.

The tabulated drawing shall consist of the following three fields (see Figures 1 and 2 for sample layouts):

— drawing field in accordance with 5.1.2;

— table field in accordance with 5.1.3;

— title field in accordance with 5.1.4.

5.1.2 Drawing field

In this field, a schematic drawing of the optical element (e.g. lens, mirror, or prism) or cemented assembly shall be given, together with all information not given in the table field. A drawing scale shall be indicated and the drawing shall be a true-to-scale technical drawing.

It is sometimes desirable to exaggerate the surface deviations for non-spherical surfaces for clarity. If this is desired, a separate inset drawing not-to-scale is permitted. It shall be indicated that the inset drawing is not-to-scale; e.g. by giving an exaggeration factor along the z-axis.

The definition of a local coordinate system for each surface is possible. In this case, for every surface on the drawing the coordinate system shall be indicated in the table field. Centring tolerances and (if applicable) the datum axis for centring specification shall be indicated on the drawing as applicable per ISO 10110-6. Additionally, the surface texture specification (see ISO 10110-8) may be shown either in the drawing or the table field.

Notes, instructions and additional information are allowed within the drawing field using a leader line, or may be numbered and tabulated, with a notes table placed in the drawing field in any convenient location. Each note shall have a number for ease of reference.

5.1.3 Table field

This field contains dimensions, tolerances, surface treatment and coating references, permissible material imperfections of the optical element or cemented assembly, and local coordinate system references, if any. The table field is subdivided into subfields.

The number and contents of the subfields depend on the type of component or assembly being specified. Whenever possible, the table subfields should follow the path of the light. Table 1 lists detailed descriptions of the properties which may be indicated. In the event that the local coordinate system for each surface is provided, it shall be indicated directly below the surface label. See 5.3 for more information and Figures A.16 and A.17 for examples of local coordinates.

a) In the case of a single element with two optical surfaces:

— the left subfield refers to the left surface (or, if desired, surface 1) of the optical element;

— the central subfield refers to the material specification;

— the right subfield refers to the right surface (or, if desired surface 2) of the optical element.

See Figures A.1, A.2, A.3 and A.4.

b) In the case of a single element with three or more optical surfaces:

— each surface subfield (e.g. A1, A2, etc.) shall be labelled, and the surface indicated in the drawing;

— the subfield labelled "Material" shall be for the material specifications;

— the subfields can be horizontally or vertically aligned;

— whenever possible, the table subfields should follow the path of the light.

See Figures A.5, A.6, A.7 and A.8.

c) In the case of a cemented assembly:

— the minimum number of subfields equals the number of surfaces;

— additional subfields may be included which identify the element information such as element number, drawing number, or part number, either in the same row as the surface subfields or above the surface subfields. For clarity, a label for these additional subfields is recommended;

— cemented or contacted surfaces are counted as one surface, and information about the interface such as tolerances on the thickness and wedge of the cement or contact area may be given in the surface field.

See Figures A.9 and A.10.

d) In the case of a cemented assembly without individual element drawings; fully tabulated:

— the number of subfields depends upon the number of elements;

— each element has a subfield for a left surface, a material, and a right surface;

— each interface between elements has a subfield where information about the interface such as tolerances on the thickness and wedge of the cement or contact area are shown.

See Figure A.11.

e) In the case of a cemented assembly without individual element drawings; partially tabulated:

— the number of subfields depends upon the number of elements;

— each element has a subfield for each surface;

— the subfields shall be ordered left to right, or as numbered on the drawing

— each interface between elements has a subfield where information about the interface such as tolerances on the thickness and wedge of the cement or contact area are shown;

— the materials tolerances are indicated with a leader line in the drawing field.

See Figure A.12.

f) In the case of a system (e.g. an assembly with air spaces) with individual element drawings; partially tabulated:

— the number of subfields depends upon the number of elements;

— an additional table of system attributes may also be shown.

See Figure 35.

5.1.4 Title field

This field is provided for general indications. This shall include a reference to ISO 10110, the reference wavelength, and other indications such as name, type and/or reference number of the optical element or cemented assembly, part number, designer and/or approver's name, and company name and logo, if desired.

5.1.5 Alternative drawing layout

While the tabular format is preferred, it is not required. An alternative layout is allowed which has only a drawing field and a title field. In this case, all surface and materials tolerances are indicated in the drawing field with leader lines to the appropriate material or surface.

See Figures A.13, A.14 and A.15.

5.1.6 Examples

Annex A gives examples of indications for optical elements and cemented assemblies.

	Drawing field *Contents in accordance with 5.1.2*	
	Table field *Contents in accordance with 5.1.3*	
Surface 1	Material specification	Surface 2
R or Surface type $\varnothing_e$ Protective chamfer λ (circled) 3/ 4/ 5/ √ 6/	 n v 0/ 1/ 2/	R or Surface type $\varnothing_e$ Protective chamfer λ (circled) 3/ 4/ 5/ √ 6/
Indications in accordance with ISO 10110	*Title field* *Indications in accordance with 5.1.4* λ = 633 nm	

Figure 1 — Tabular indication of data for a single element

Drawing field Contents in accordance with 5.1.2			
Table field Contents in accordance with 5.1.3			
Surface 1	Surface 2	Surface 3	Surface 4
Ø e λ 4/ 6/	Ø e λ 4/ 6/ Cement:	Ø e λ 4/ 6/ Cement:	Ø e λ 4/ 6/
Indications in accordance with ISO 10110		Title field Indication in accordance with 5.1.4 λ = 546,07 nm	
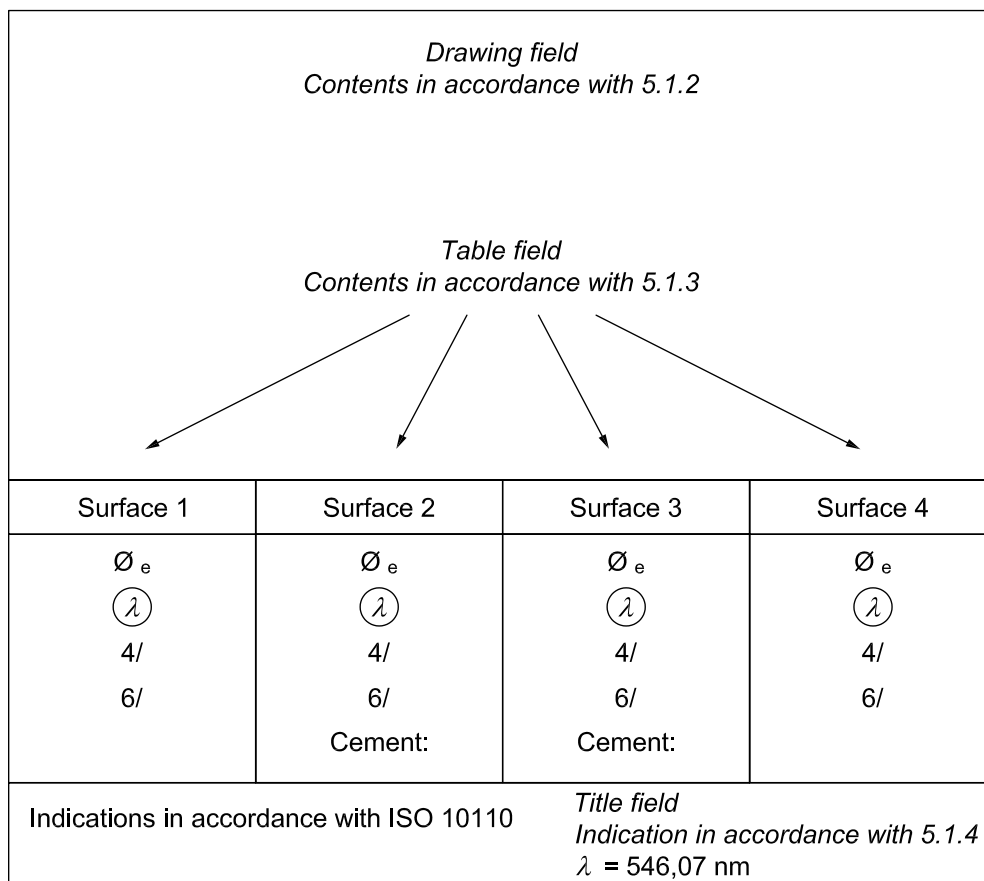
NOTE   5/, 13/ and/or 15/ specifications can be added to the table field if appropriate.

Figure 2 — Tabular indication of data for a cemented assembly (triplet)

5.2   Views

Optical elements shall be shown with incident light entering from the left and the optical axis horizontal, unless otherwise specified. Rotationally invariant parts and assemblies may be shown with just one cross section drawing.

The preferred method is that components be drawn in cross section and hatched with short-long-short strokes in accordance with ISO 128-50, as shown in Figure 3. Back edges and hidden lines should normally be omitted. However, for the sake of clarity, such lines may be included.
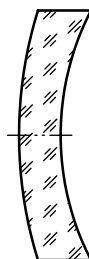
Figure 3 — Hatching

Components of subassemblies, such as cemented components, shall be hatched in alternate directions.

For the purpose of simplification, optical parts may be drawn without hatching, as shown in Figure 4. Mixing of hatched and unhatched parts in one drawing shall not be used.
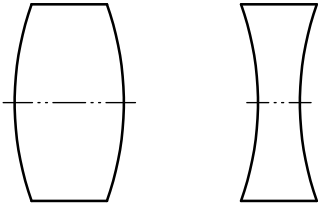
Figure 4 — Simplified drawings of lens elements

Lens elements with surfaces having two meridians of symmetry, such as cylindrical and toric surfaces, shall be drawn in two cross sections corresponding to these meridians (see Figures 5 and 6).

Figure 5 — Rectangular cylindrical lens element

Figure 6 — Square toric lens element

5.3 Global and Local Coordinate Systems

It is sometimes necessary to indicate local coordinate systems to describe complex surface shapes. This is often the case with parts that are drawn using the generalized surface descriptions given in ISO 10110-12 and ISO 10110-19. When required, a right-hand orthogonal Cartesian coordinate system shall be drawn as follows: two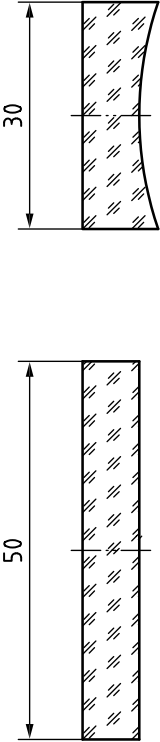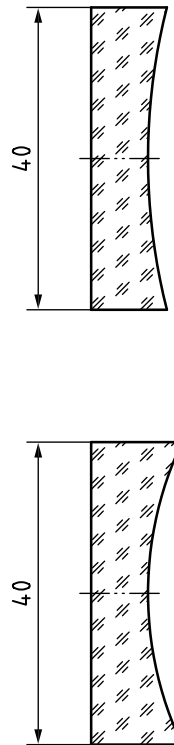 lines with line type 01.2, ISO 128-24 perpendicular to each other shall indicate two of the three axes (typically the Z and Y axes). The positive direction of each axis shall be indicated by an arrowhead which is labelled by an axis identifier ("z", "y"). The missing X axis which either points into or onto the plane of projection should be indicated in the form of a circle with either a centred point (out of the page) or a cross (into the page) (see Figure 7). If only one coordinate system is shown in the drawing field, it shall be the global coordinate system. If additional coordinate systems are shown in the drawing, the global coordinate system axes shall be indicated with a subscript G, and other coordinate system axes shall be indicated with a subscript by surface (e.g. "z_1", "z_2" for surface 1 and 2).

It is recommended that all three axes be indicated, however it is important to note that, since all coordinate systems are right-handed, it is possible to indicate only two of the three axes, and the direction of the third axis can be inferred. Examples of this are shown in Figures 8 and 9.

If local coordinate systems are used, and the global coordinate system is not the coordinate system of the first surface, the global coordinate system shall be indicated in the drawing field.

All local coordinate systems shall be indicated with respect to the global coordinate system. The local coordinate systems shall be indicated by coordinate transformations between the global coordinate system and the local coordinate systems of the individual surfaces. In these cases the local coordinate system for each surface is illustrated in the drawing field. Each surface shall have a set of global reference values, which describe the position of the local coordinate system with respect to the global one. Each set consists of six values; a, b, c, α, β, and γ. To move from the global coordinate system to the local coordinate system, one has to first translate along the x, y, and z axes by the indicated translation amounts a, b, and c (the order of translation is irrelevant because they are orthogonal). Secondly rotate around the new x axis by the angle α. Then rotate around the new y axis by the angle β and finally around the new z axis by the angle γ. The rotations are right-handed. When they are required, the

specifications of the local coordinate system shall be the first entry in each surface description in the tabular field. The entry shall be in the following form:

(a, b, c), α, β, γ

The units for α, β, and γ are degrees and the units for a, b, and c in the declared unit for dimensions. References should be used in order to link the surfaces to measureable datums of the part.

If the global coordinate system is the coordinate system of the first surface, the local coordinate system of the first surface shall be indicated as (0, 0, 0) 0°, 0°, 0°.

ISO 10110-19 includes more information on local and global coordinate systems and how they relate.
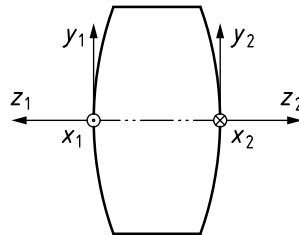
Figure 7 — Coordinate systems with all axes
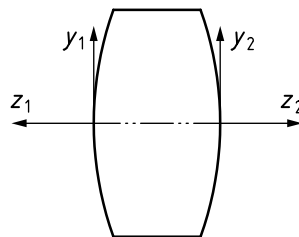
Figure 8 — Coordinate systems without X axis
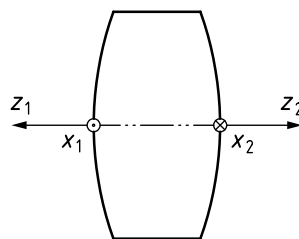
Figure 9 — Coordinate systems without Y axis

5.4 Axes

Axes shall be drawn as follows:

Rotation axes, axes of symmetry, and centre lines: Line type 04.1, ISO 128-24

Optical axis, beamline or base ray: Line type 05.1, ISO 128-24

If an optical axis coincides with a rotation axis or centre line, the optical axis shall be drawn. An intentional displacement or tilt of axes (e.g. of the centre line of an element with respect to the optical axis) shall be indicated and dimensioned (see Figure 10). Very small shifts may be drawn out of scale to exaggerate the displacement. Exaggerated dimensions shall be underlined.
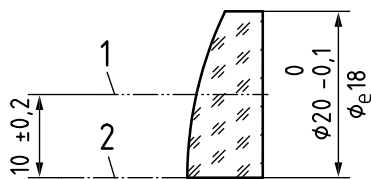
Figure 10 — Axes

5.5 Leader lines

Leader lines shall have a dot at the end for leaders terminating within the outline of a part (see Figure 11), and an arrowhead for leaders terminating on the outline (see Figure 12). Arrowheads shall touch the edge or surface in order to prevent misunderstanding.
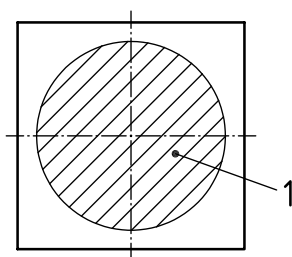
Figure 11 — Leader line to an area
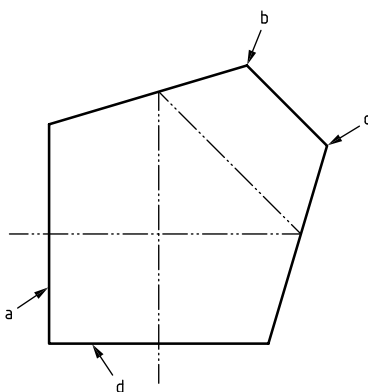
Figure 12 — Leader lines to edges and surfaces

5.6 Test regions

If testing of a complete surface or volume is not required, the test regions or optically effective surfaces shall be shown on the drawings. If no test region is indicated, but an effective aperture is indicated, then the test region shall be the effective aperture. For example, in the case of circular parts if the diameter of the circular test region is not otherwise defined, the "effective diameter", indicated by "$\emptyset_e$" shall be the diameter of the test region. (see Figures 13, 23, A.1 and A.2). It defines the region of the component surface that has optical significance[3].

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3)   Former practice (and specification of the 1996 edition of ISO 10110-1) has been to assign the effective diameter to a surface by a leader line. This former practice could be misinterpreted as an indication for the radius of curvature.
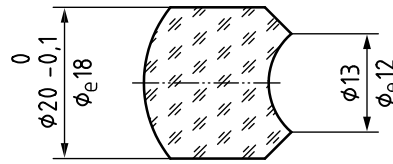
Figure 13 — Test regions

The boundaries of test regions shall be drawn in continuous narrow lines (line type 01.1, ISO 128-24) and the regions themselves shall be hatched in continuous lines of the same type. They may be subdivided into sub-regions to which different tolerances apply, if required. In such cases, the sub-regions shall be numbered to clarify their relationship. The sub-region number shall be indicated by a leader to the appropriate area (see Figure 14).
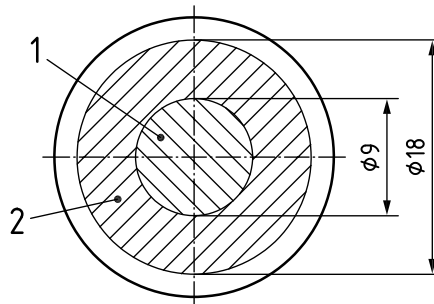
Figure 14 — View showing test regions

Where necessary, special views entitled "test regions" shall be added showing optically effective regions and provided with appropriate dimensional data. If symmetrical components have different test regions (e.g. due to the path of the rays being divergent or convergent) then the regions in question shall be suitably identified to prevent incorrect assembly. The same requirement applies if dissimilar test specifications are to be applied to similar test regions. The method of identification should be explained in the drawing (see Figure 15).

NOTE   Since effective diameters and test regions are not per se geometrically tolerated, the designer may have to add further definitions, if necessary.

If a test region or effective diameter is not shown, the surface counts in its full extent as the test region. Note that bevels and chamfers do not count as part of this test region.

5.7   Test fields

A test field can be defined in any shape (e.g. circular, rectangular) and shown in any position within the test region as a dimensioned area defined by a thin continuous line. Appropriate requirements indicated by a leader to this test field shall apply to all possible positions of the test field within the test region. In this case the geometric shape of the test field shall be appended to the appropriate tolerance indication as follows: "…(all $\emptyset$…) or (all … x …) (see Figure 16).

5.8   Test volumes

A test volume shall be indicated if a volume of defined extent has to fulfil higher requirements than the rest of the optical element. The boundaries shall be drawn in continuous narrow lines, line type 01.1, ISO 128-24 (see Figure 17).
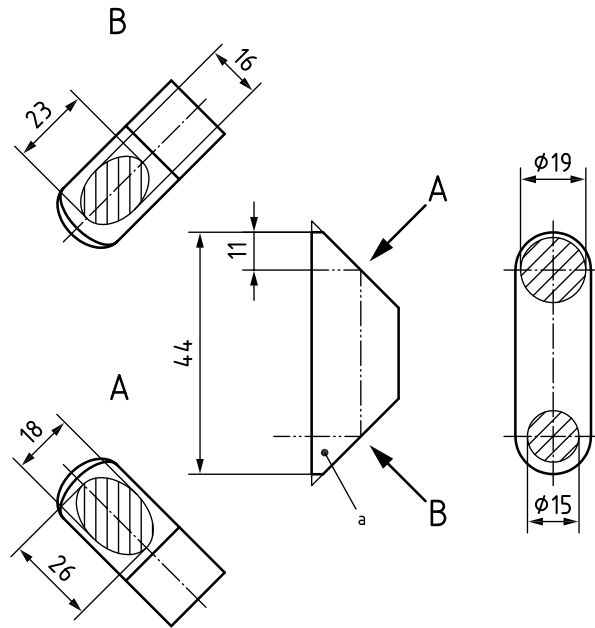
^a Mark for identification.

Figure 15 — Different test regions for a prism
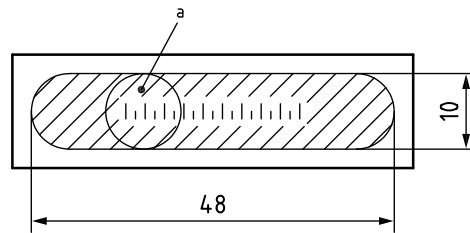
^a Tolerance (all ⌀ 10 mm).

Figure 16 — Test field within a test region
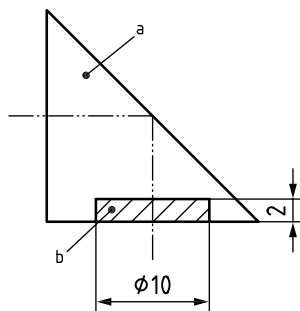
^a Normal tolerance for bubbles.
^b Special tolerance for bubbles.

Figure 17 — Test volume

5.9 Dimensioning

5.9.1 General

Fundamentally, the dimensions for optical elements relate to the finished state and therefore include surface treatment such as painting and/or coating. However, in certain cases the dimensions of a part before the application of surface treatments are important. In such cases it shall be explicitly indicated in the drawing that these dimensions refer to the untreated part.

5.9.2 Radius of curvature

Spherical surfaces are defined by stating the radius of curvature with a dimensional tolerance (see Figures 18 to 20).

To distinguish between a convex and a concave surface, especially in the case of a weak curvature, the arrow on the leader for the radius indication shall always appear to start from the centre of curvature. Alternatively, a convex surface may be indicated by the letters CX following the radius of curvature indication, and a concave surface by the letters CC. This tolerance shall indicate the range within which the actual surface shall be contained. If the radius of curvature and its tolerance are not indicated in the drawing field, they shall be indicated in the table field.
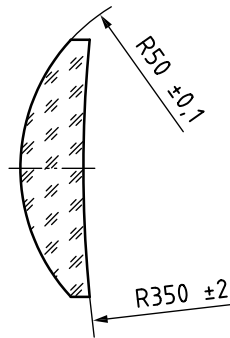
Figure 18 — Radii for a meniscus lens element
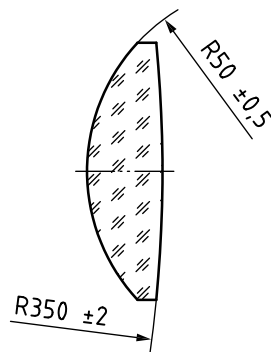
Figure 19 — Radii for a biconvex lens element
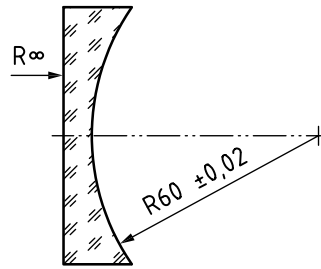
Figure 20 — Radii for a plano concave lens element

Alternatively, the radius of curvature tolerance may be given in whole or in part in interferometric terms as defined in ISO 10110-5.

If the total permissible variation of the radius of curvature is given in interferometric terms, the dimensional tolerance of the radius is zero and need not be included in the indication of the radius of curvature.

For plane surfaces (i.e. infinite radius of curvature) the radius shall be indicated by the symbol "R∞" or "PL". The tolerance on flatness shall be indicated in interferometric terms (see ISO 10110-5).

For toric and cylindrical surfaces, two views are required, as described in 5.2.

For cylindrical surfaces, the radius shall be indicated by the term as "CYL".

NOTE   In prior versions of this document, a cylindrical surface was indicated by the term Rcyl.

For aspheric surfaces, the surface shall be indicated by the term "ASPH" and the surface description, including the base radius, shall be written in accordance with ISO 10110-12.

For conic surfaces, such as paraboloid, ellipsoid, or hyperboloid surfaces, or for other surfaces of second order, the surface shall be indicated by its canonical shape (e.g. "hyperboloid", or "toroid") followed by the radius, conic constant or other terms required to define the surface. The surface equation shall be given in a note. For more information, see ISO 10110-12.

For other surfaces, the surface shall be indicated by the term "GS" and the surface description shall be written in accordance with ISO 10110-19.

5.9.3   Thickness

The thickness shall be indicated as a nominal size with a tolerance. In the case of lens elements having concave surfaces, the overall thickness should be indicated in addition to the axial thickness (see Figures 21 and 22). If either the center thickness or overall thickness is given as reference only, it shall be shown in brackets.

Figure 21 — Thickness indication for a biconvex lens element
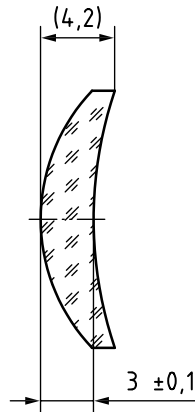
Figure 22 — Thickness indications for a meniscus lens element

5.9.4 Diameter

The diameter of optical parts shall be indicated together with tolerances. The optically effective diameter "$\emptyset_e$" shall be added, if required (see Figure 23).
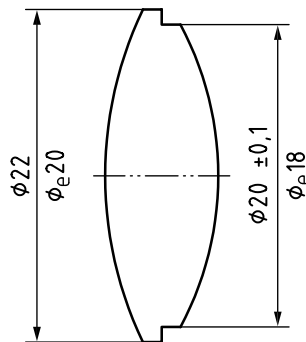
Figure 23 — Diameters and optically effective diameters

5.9.5 Presentation of shapes of edges, bevels and chamfers

5.9.5.1 General

The shape of edges, bevels and chamfers is either determined for design (functional) reasons, or for protective purposes to prevent chipping of sharp edges and corners during production and handling.

5.9.5.2 Sharp edges

An edge that has to remain sharp for functional reasons is shown by the symbol "0" (see Figure 24). Imperfections in this edge are usually controlled with the edge chip requirement in the 5/ notation of the adjoining surfaces. Alternately the designer shall indicate the explicit allowed burr or undercut allowance for the edge in a note.
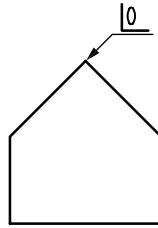
NOTE   Sharp edge imperfections shall be less than 0,02.

Figure 24 — Sharp edge

5.9.5.3   Functional bevels

A bevel is a functional surface replacing a sharp edge, and shall be completely specified with respect to dimension, tolerance, inclination and, if necessary, centring (see Figure 25).
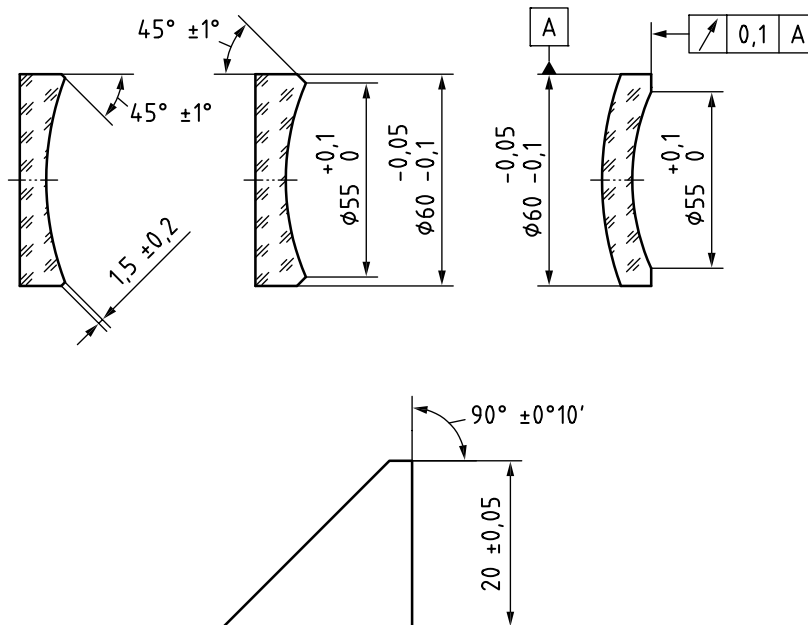
Figure 25 — Dimensioning of bevels

5.9.5.4   Non-functional edges and corners

A protective chamfer is a small surface replacing an edge or corner, approximately equally inclined to the surfaces forming the edge or corner. This surface does not need to be individually drawn.

The indication "protective chamfers" shall be included as a note on the drawing to cover all edges and corners that are not individually specified, see Figure 27. The width, W, of a chamfer is shown in Figure 26. The minimum and maximum permissible widths of the chamfers shall be indicated in a note.

Inside edges: because a perfectly sharp inside edge cannot be produced, it is often necessary to specify the maximum (and occasionally the minimum) permissible width of the edge surface (see Figures 28 and 29). If only one value is indicated, it shall be interpreted as the maximum permissible width.
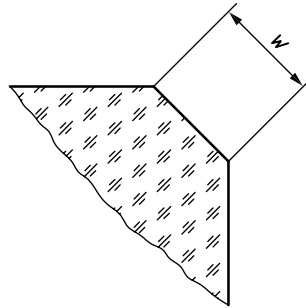
Figure 26 — Width, W, of a protective chamfer
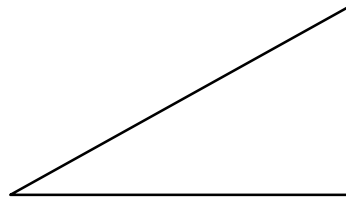
NOTE   Protective chamfers 0,2–0,5.

Figure 27 — Indication of protective chamfers
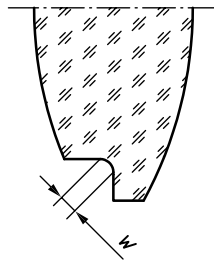
Figure 28 — Width, W, of inside edge
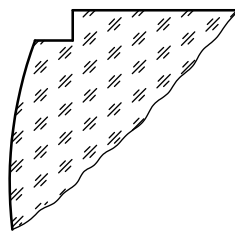
NOTE   Inside edge 0,2–0,5.

Figure 29 — Indication of inside edge

5.9.6 Linear dimensions

The nominal dimensions for length, width and height (or diameter and thickness) of a part shall be stated with permissible tolerances. Parts specified to have protective chamfers or small bevels shall be dimensioned without regard to the chamfers or bevels.

On prisms with surface edges that are not 90 degrees, i.e. where the linear dimension cannot be measured, the dimensions refer to the theoretical intersection of the surfaces ("sharp edge condition").

Such dimensions shall be identified by adding the word "theoretical", or the abbreviation "theor." to the indication (see Figure 30).
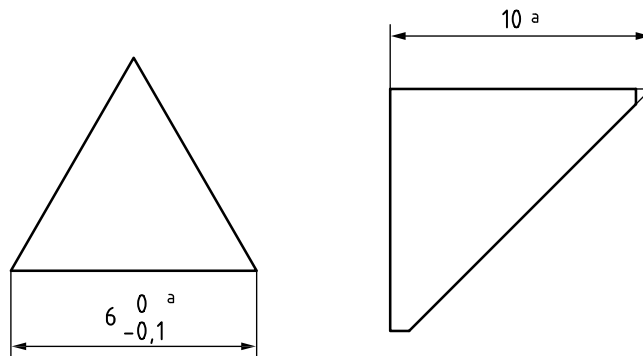
^a Theoretical.

Figure 30 — Linear dimensions for prisms

5.9.7 Angles

The nominal values with tolerances shall be stated in the drawing. The surfaces in question shall be indicated by capital Roman letters (see Figure 31).

Figure 31 also shows an example of the indication of angles and their tolerances. The angle between a plane containing the normals of two surfaces and the normal to any other surface is called a "pyramidal deviation". Pyramidal deviation is specified in the form

pyr AB, C < n

where pyr indicates a pyramidal deviation, n is the allowed angular deviation from the surface normal of surface C to reference plane which contains the surface normals for A and B.

The optical ray path and deflection angle may be shown. The deflection angle is the angle between the directions of the incident and emergent rays. Unless otherwise specified, the incident ray shall be perpendicular to the entrance surface. If specified, the deflection angle shall be given with a ± tolerance (see Figure 32).

A tolerance in the ray deviation with respect to the datum plane or axis may be indicated using the 14/ notation of ISO 10110-6 as shown in Figure 32.

NOTE   This use of the 14/ notation is not fully described in the current edition of ISO 10110-6, however it is a clear and unambiguous way to indicate the ray deviation tolerance. The notation will be described more fully in a future revision of Part 6.

45° ±30″

B

A

E

90° ±30″

112°30′ ±30″

D

a
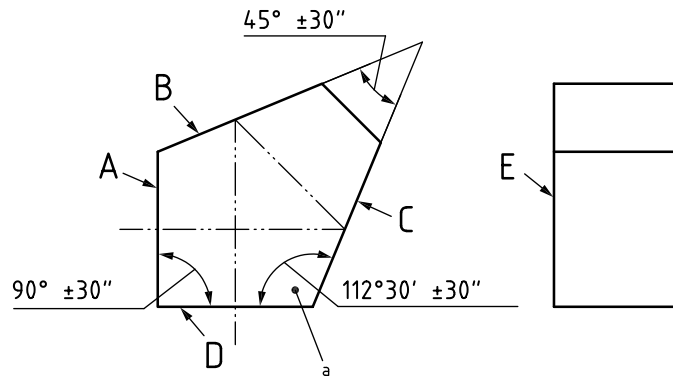
∢ A, E = 90° ± 10'

∢ D, E = 90° ± 10'

pyr AD, C < 1'

a   Mark for identification.

∢ B, E = 90° ± 3'

∢ C, E = 90° ± 3'

pyr AD, B < 1'

Figure 31 — Angles with tolerances

90° ±0°0′1″

14 /3′ A

A

a
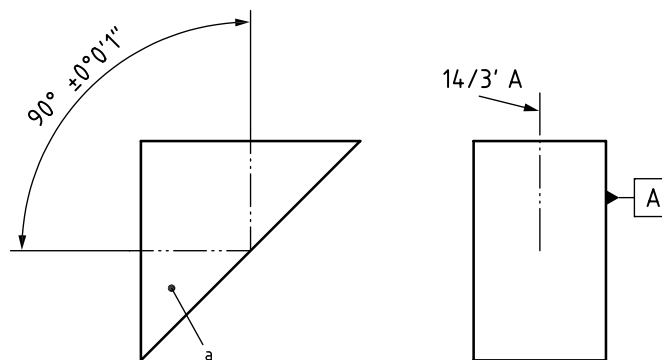
a   Mark for identification.

Figure 32 — Prism deflection angles

5.9.8   Special surfaces

Special optical surfaces shall be indicated by a special surface symbol (see Figure 33) tangentially placed at the surface and a note field in a box which identifies the special surface type and the special surface information necessary (e.g. diffractive order number, period, blaze), or a reference to a separate document that describes the special surface. The box, circle and connection line shall all be a continuous thin line type 01.1 in ISO 128-24. See Figure A.4. Additionally, the special surface symbol and information can be tabulated, similar to the method used for coatings. See for example Figure A.1.

Ⓢ

Figure 33 — Special surface symbol

5.10 Material specification

5.10.1 General

The information required to define the material shall be entered in a box on the drawing.

The following information shall be given, as appropriate:

a) Indication of material, e.g.:

— manufacturer, material type; or

— international glass code number; or

— refractive index and Abbe number, including an indication of the reference wavelength; or

— chemical description (for example for crystalline material);

b) material requirements, such as:

— specifications and/or tolerances for refractive index and dispersion (especially important for optical glass), transmission (versus wavelength), birefringence, fluorescence, coefficient of thermal expansion (CTE), raw glass specifications defined in ISO 12123, crystal properties (e.g. mono- or polycrystalline) and orientations with respect to the optical axis (see 5.10.2 for more information); and

— specifications and/or tolerances for "chemical characteristics or properties" (important for climatic, acid, alkali, stain resistance, etc.), and mechanical properties (like hardness) that are sometimes important for processing.

Material properties and tolerances that refer to homogeneity, striae, bubbles, and stress birefringence in the individual optical element shall be specified in accordance with ISO 10110-18.

5.10.2 Crystallographic axes

When the optical material is crystalline it may be necessary to indicate the crystallographic axes directions on the drawing. Examples of ways of indicating the axes can be found in IEC 60758:2016 Figures 1, 3 and 9.

When using Miller indices to indicate axis direction, the Miller indices are specified with square brackets e.g. [110] or [2 $\overline{1}$ 1]. Alternatively miller indices can indicate the crystallographic plane of a surface of the element, in which case round brackets are used e.g. (110).

5.11 Indication of optical tolerances and various properties

5.11.1 Tolerances for the position of the local coordinate systems

The rules for indicating tolerances for the position of local coordinate systems are given in ISO 10110-6.

5.11.2 Optical properties and tolerances

Optical properties and tolerances shall be indicated using the symbols shown in Table 1 and the other parts of ISO 10110, and either the tabular format described in 5.1, or with a leader line to the appropriate surface or volume. Instructions for the indication of numerous properties and tolerances specific for optical parts are given in the various parts of ISO 10110.

Table 1 — Properties to be listed if applicable

Items	Description
Material	Type, name and manufacturer or identification number of the material
Surface type: ASPH CYL GS ⓢ toroid, etc.	Indication of the type of surface being specified: — asphere — cylinder — general surface — special surface — other designations per ISO 10110-12
n ν	If appropriate, refractive index and Abbe number including an indication of the reference wavelength (and tolerances).
R	Radius of curvature with tolerance, if desired[a]. The direction of curvature shall be indicated as follows: — convex surface: CX — concave surface: CC — plano surface: R∞ or PL
$\emptyset_e$	Optically effective diameter
Protective chamfer	Minimum and maximum permissible widths of the protective chamfer
Ⓛ	Surface treatment and coating (i.e. ISO 10110-9)
0/	Stress birefringence tolerance (i.e. ISO 10110-18)
1/	Indication of permissible bubbles and inclusions (i.e. ISO 10110-18)
2/	Homogeneity and striae classes (i.e. ISO 10110-18)
3/	Surface form tolerance (i.e. ISO 10110-5)
4/	Centring tolerance (i.e. ISO 10110-6)
5/	Surface imperfection tolerance (i.e. ISO 10110-7)
6/	Laser irradiation damage threshold indication (i.e. ISO 10110-17)
13/	Transmitted wavefront deviation (i.e. ISO 10110-14)
15/	Assembly surface imperfections (i.e. ISO 10110-7)
√	Surface texture (i.e. ISO 10110-8)
	If appropriate, the words "To be cemented" or "To be contacted" and information about the surface interface such as bondline thickness tolerance shall be added.
NOTE Aspheres, cylinders, and other optical surfaces can require additional information to define the surface shape. See ISO 10110-12 and ISO 10110-19 for further guidance.	
[a] Other ISO symbols are defined for the radius of curvature. In particular, ISO 129-1 uses "SR" as such a symbol, which shall not be used according to ISO 10110.	

5.11.3 Optical subassembly

An optical subassembly drawing shall include, as appropriate, the following items (see Figure 34):

a)   element part numbers (or parts list reference numbers);

b)   details of cement or other method of bonding;

c)   dimensions, tolerances and necessary datums that are additional to those given in detail drawings (e.g. centring tolerance and datums);

d)   focal length and/or other requirements;

e)   special notes regarding assembly and test procedures.
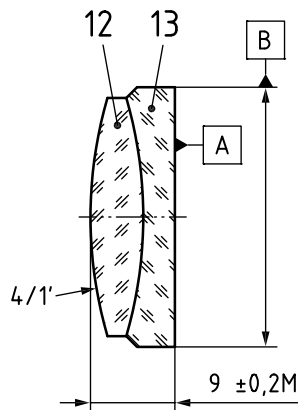
NOTE 1   Cement, according to specification # XXXX.

NOTE 2   Focal length 100 ± 0,5.

Figure 34 — Optical subassembly

The drawings of parts of subassemblies shall contain references to the assembling process, e.g. "to be cemented".

If a subassembly drawing does not contain tolerances for surface form or surface imperfections, the tolerances given in ISO 10110-11 apply after cementing (or optical contacting), where appropriate[4].

If the thickness tolerance of a compound (e.g. cemented) subassembly is smaller than the sum of the thickness tolerances of the elements forming the subassembly, so that the elements have to be matched, the thickness tolerance of the subassembly shall be identified with the capital letter "M" (see Figure 34).

6   Additional indications for optical layout drawings

6.1   General

An optical layout drawing shall show the relative positions of all components of a complete optical system and shall specify, as appropriate, the following items (see Figure 35):

a)   item references (or parts list reference numbers);

b)   datum (reference) axis for element tilt and decenter tolerances;

c)   separations, including tolerances;

d)   magnification (total and/or partial, as applicable);

e)   object distance, or range of object distances;

f)   full field of view in object space;

g)   numerical aperture or *f*-number;

h)   position and sizes of field stops;

i)   position(s) and size(s) of image plane(s);

---

4)   Imperfection tolerances for cemented surfaces taken from element drawings can need adjustment to consider the enlarged or reduced view of the imperfections through an optical element.

j)   position and sizes of pupils;

k)   dimensions of clear apertures and physical sizes of parts;

l)   position(s) and size(s) of focal plane(s);

m)   spectral passband;

n)   movements required for magnification and focus adjustment;

o)   mounting interface data;

p)   element tilt and decenter tolerances; see ISO 10110-6;

q)   special notes regarding assembly and test procedures;

r)   other performance requirements.

NOTE 1   For the sake of clarity, it is sometimes useful to indicate certain data in tabular form.

NOTE 2   In cases where optical systems have complex, folded paths it can be necessary to show isometric views.

Ind. acc. ISO 10110
$\lambda = 632,8$ nm

TELESCOPE 7 x 14

^{a} Focus adjustment
^{b} Eyepiece focus
Variation ±5 m^{-1}

Table 1

Serial number	Component and focal length	clear aperture	tilt and decenter tolerance
1	achromatic lens $f = 63$	ϕ_e 14	4/5'(0,1)
2	reticle, cemented	ϕ_e 6	4/20'(0,05)
3	front lens of eyepiece	ϕ_e 9	4/10'(0,05)
4	rear lens of eyepiece	ϕ_e 9	4/10'(0,05)
3 + 4	eyepiece $f = 9$	ϕ_e 9	4/30'(0,1)

Table 2

System attribute	Value	
Magnification	7 ×	
Object space field of view	5,89 degrees	
Entrance pupil diameter	14 mm	
Eye relief	8 mm	
Spectral band	(450 – 650) nm	

Scale 1:1

Figure 35 — Optical layout drawing

6.2 Axial separations

6.2.1 General

Separations between the elements shall be indicated along the datum axis (see ISO 10110-6). For axially symmetric systems this axis is the centre line.

Distances that are to be adjusted during assembly, or varied during use, shall be indicated on the optical layout drawing, together with a short explanatory note giving the reasons for the adjustment or variation.

6.2.2 Fixed axial separations

Fixed separation distances shall be shown by the nominal design dimension with the permitted tolerance (see Figure 36).

1,8 ±0,05
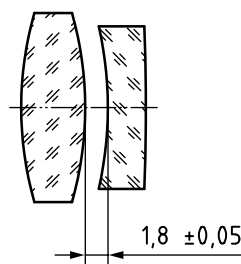
Figure 36 — Air space between lens elements

6.2.3 Adjustable axial separations

During assembly, some axial separations may be varied within predetermined limits in order to achieve a specific condition or requirement. Such adjustable distances shall be identified with the capital letter "A", and the reason for the adjustment shall be given in a note. If necessary, the required accuracy of adjustment shall also be given. The dimensional information shall be shown on the drawing in the following order (see Figure 37):

a)   the letter "A" to identify that the distance is to be adjusted;

b)   the nominal distance;

c)   the permissible limits of adjustment from the nominal value.

A [a] 60 ±0,5
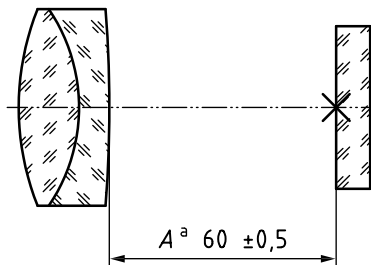
[a]   Adjust for best focus, accuracy of adjustment ± 0,02.

Figure 37 — Adjustable axial separation

25

6.2.4 Variable axial separations

Some axial distances may need to be varied by the user of the complete system. These shall be identified by the letter "V". The extent of variation together with the reason for the variation shall be shown in the drawing (see Figure 38). If necessary, the required accuracy shall also be given.

V ᵃ 5 ±1
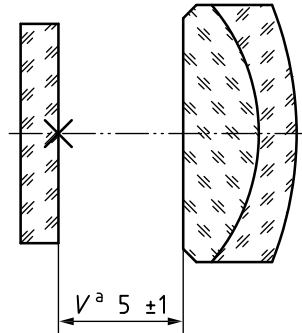
ᵃ   Eyepiece focus variation ± 3 m⁻¹.

Figure 38 — Variable axial separation

6.3   Images, pupils, field stops and other apertures

Positions and sizes of images, pupils, field stops and other apertures in optical layout drawings shall be drawn as follows:

a)   the position of an image shall be drawn as a cross (line type 01.2, ISO 128-24) on the optical axis (see Figures 39 and 40);

b)   the position of a pupil shall be drawn as a short continuous thick line (line type 01.2, ISO 128-24) across the optical axis (see Figure 41);

c)   physical apertures shall be drawn as continuous thick lines (line type 01.2, ISO 128-24) defining position (see Figures 42 and 43);

d)   sizes of physical apertures should be drawn as continuous narrow lines (line type 01.1, ISO 128-24) perpendicular to the axis (see Figures 42 and 43);

e)   other apertures shall be drawn in a similar manner, but in dashed thick lines (line type 02.2, ISO 128-24) (see Figure 44).
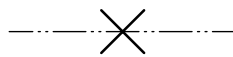
Figure 39 — Indication of image position (in space)
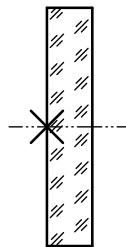
Figure 40 — Indication of image position (on a surface)
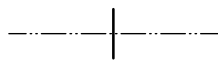
Figure 41 — Pupil position

If required, field stops shall be marked FS_1, FS_2, etc., pupils shall be marked P_1, P_2, etc., following the path of the incident light (see Figures 42 and 43).

Dimensions of field stops, pupils and images shall be shown adjacent to the stop, pupil or image (see examples in Figures 42 to 44).
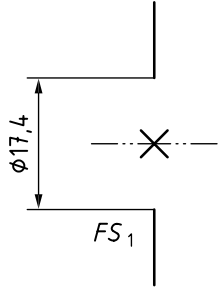
Figure 42 — Physical aperture (field stop)
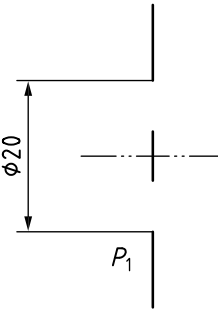
Figure 43 — Physical aperture located at the pupil P_1
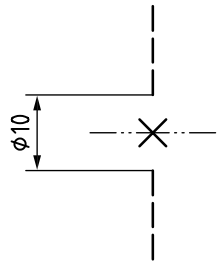
Figure 44 — Image without physical aperture

Annex A
(informative)

Examples of drawings of optical elements

Ind. acc. ISO 10110; λ = 546,07 nm

left surface	material	right surface
R 37,449 CX ϕ_e 30,5	Company / N–LAK7	R ∞ ϕ_e 29
chamfer 0		chamfer 0

3/5,0(1,0)
4/1,4'
5/5 × 0,1; C5 × 0,16; L3 × 0,004;
  E0,04
$\textcircled{\lambda}$ AR 209,1060
$\textcircled{S}$ specification 4710 – 1815/01
	n_e 1,65425 ±0,001
	v_e 58,26 ±0,5%
	
	0/20
	
	1/5 × 0,1
	2/1;2
		3/5,0(1,0)
		4/–
		5/5 × 0,1; C5 × 0,16; L3 × 0,004;
		  E0,04
		$\textcircled{\lambda}$ AR 209,1060

Scale 1:1
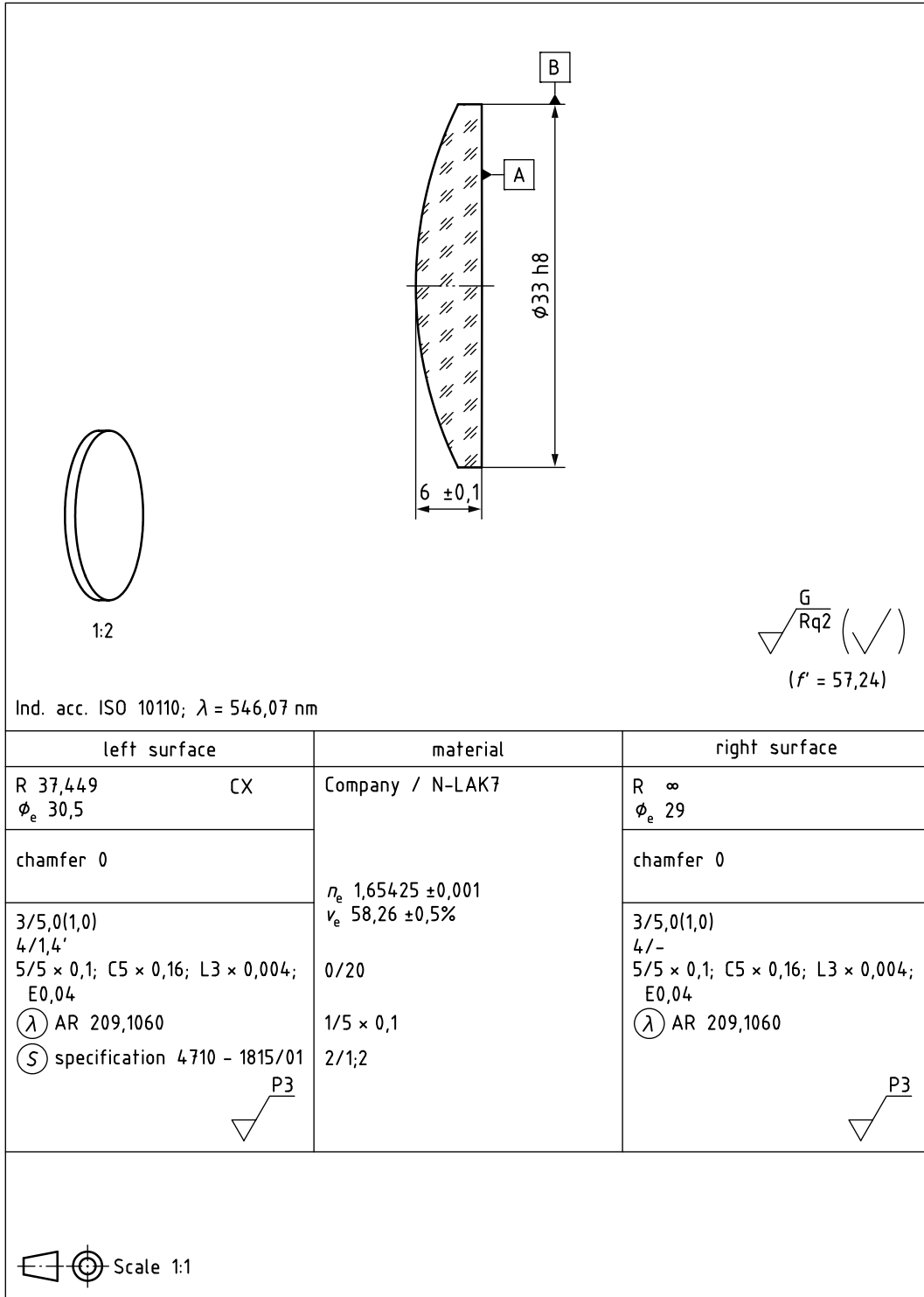
Figure A.1 — Example of lens element drawing

Ind. acc. ISO 10110; λ = 546,07 nm

left surface	material	right surface
R 37,67 CC ϕ_e 35	Company / N–BK7	R 50,17 CX ϕ_e 34
		chamfers: 0–0,2 / inside edges 0–0,2
	n_e 1,51872 ±0,001 v_e 63,96 ±0,5%	
3/2(0,5) 4/– 5/5 × 0,16; L2 × 0,04; E0,5 λ AR 209,1060 P2	0/10 1/5 × 0,16 test volume 1/3 × 0,1 2/1;2	3/3(1,0) 4/2' 5/5 × 0,16; L2 × 0,04; E0,5 test region: 5/3 × 0,1; L1 × 0,04 λ to be cemented P2

Scale 1:1
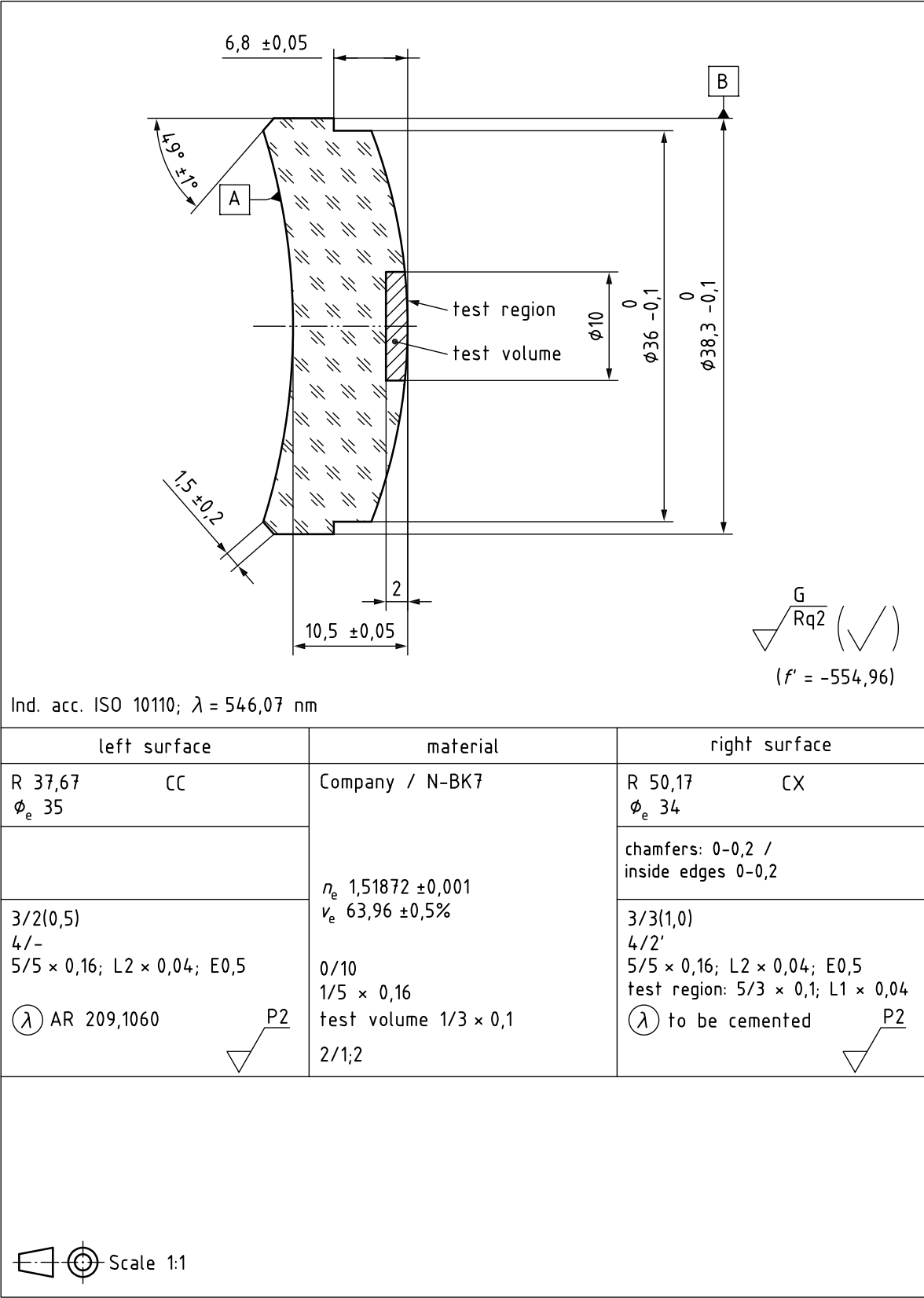
Figure A.2 — Example of lens element drawing

left surface	material	right surface
R 37,449 CX ϕ_e 30,5	Company / N–LAK7 n_e 1,65425 ±0,001 v_e 58,26 ±0,5%	PL ϕ_e 29

3/5,0(1,0)
4/1,4'
(λ) AR 209,1060
6/6 kWcm^{-2}; 1064 nm; 20 ns
  $\overline{\underset{\diagdown}{P2}}$
	
	0/10
	1/5 × 0,1
	2/1;2
		3/5,0(1,0)
		4/–
		5/5 × 0,1; C5 × 0,16; L3 × 0,004;
		  E0,04
		(λ) AR 209,1060
		6/6 kWcm^{-2}; 1064 nm; 20 ns

test subregion 1 5/5 × 0,05; C5 × 0,16; L3 × 0,004		
test subregion 2 5/5 × 0,15; C5 × 0,16; L3 × 0,004; E0,06		$\overline{\underset{\diagdown}{P2}}$

Ind. acc. ISO 10110; λ = 546,07 nm

Scale 1:1
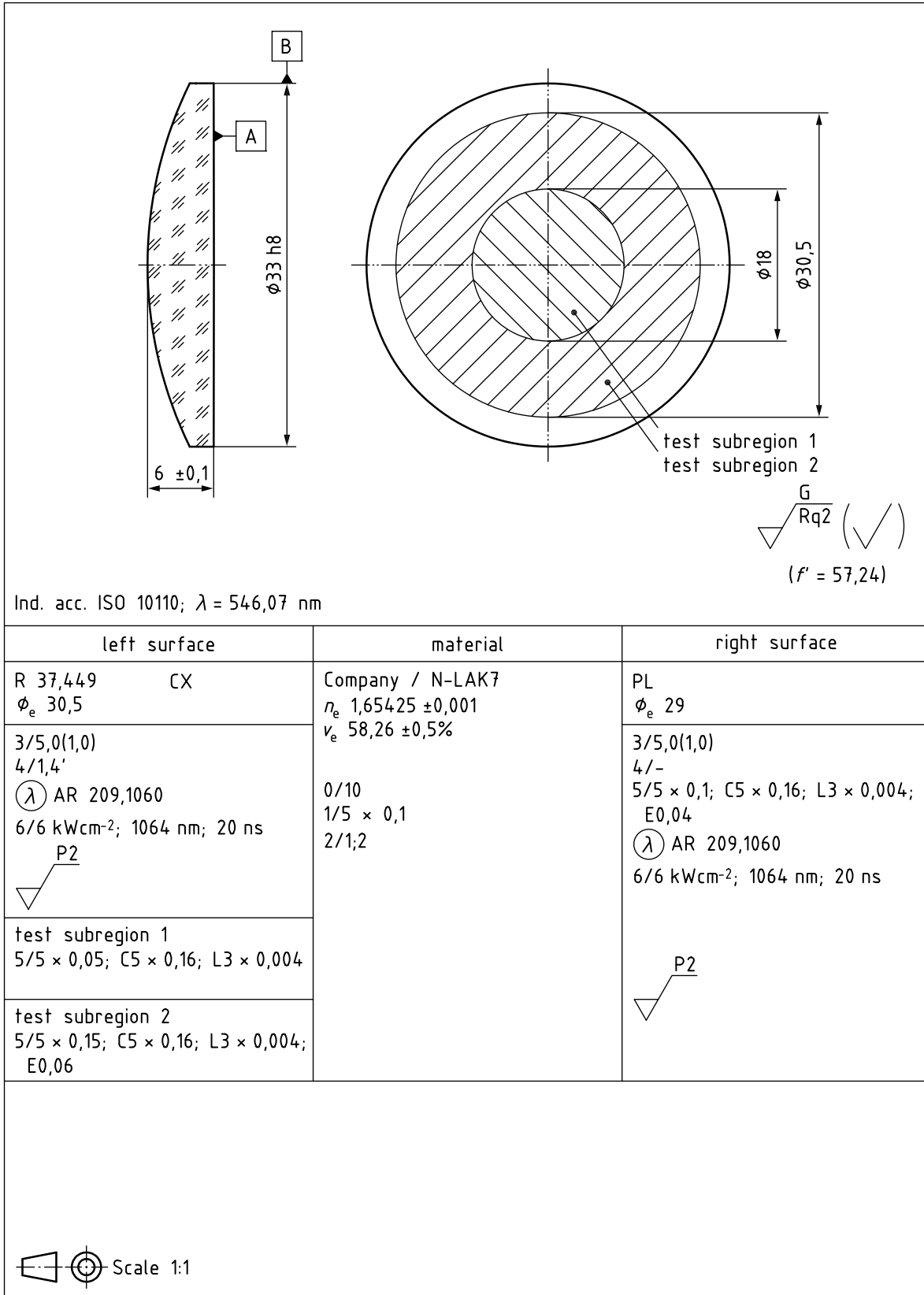
Figure A.3 — Example of lens element drawing

Holographic grating
Construct Y1 – 27,248 ±0,005
Construct Z1 – 59,796 ±0,005
Construct Y2 – 9,606 ±0,005
Construct Z2 – 58,922 ±0,005
Construct λ – 532 nm
Diffraction order –1

$\phi 20 \pm 0,1$

4 ±0,1

S

Ind. acc. ISO 10110; λ = 546,07 nm

left surface	material	right surface
R 29,0　　　　CC ϕ_e 18	Company / N–BK7	PL ϕ_e 19
chamfer 0,1 – 0,5		chamfer 0,1 – 0,5
3/4(1/0,5) 4/0,1' 5/3 × 0,4; C3 × 0,25; L1 × 0,020; 　E0,5 　P3 0,002 – 0,08 Rq 0,005	n_e 1,51872 v_e 63,96 0/25 1/3 × 0,4 2/–	3/10(5/2) 4/0,1' 5/ P

G/Rq2 (P3)

Scale 2:1

Figure A.4 — Example of a lens element drawing with a special surface indication
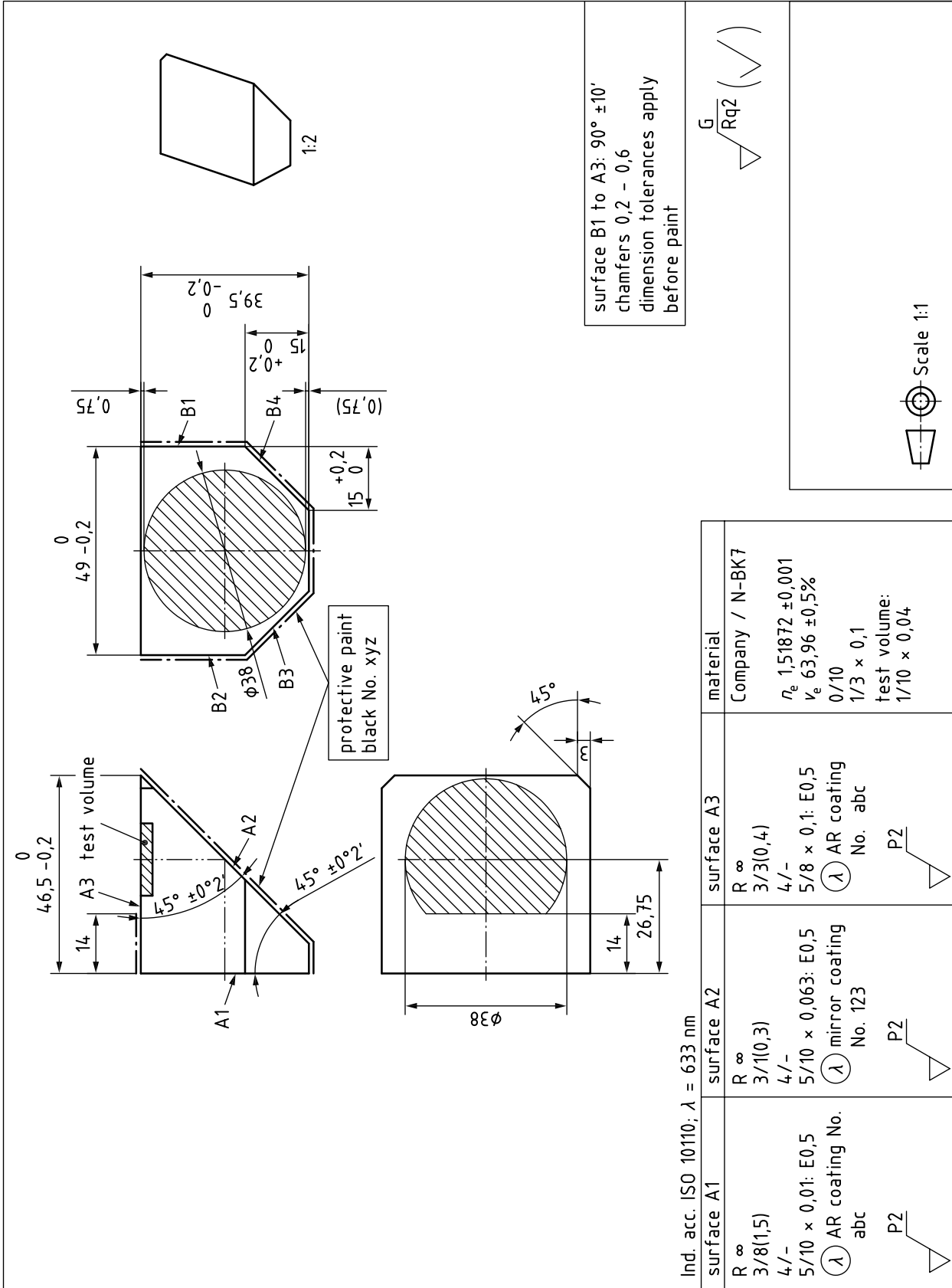
Figure A.5 — Example of a tabular element drawing with more than two surfaces; vertically aligned

surface B1 to A3: 90° ±10'
chamfers 0,2 – 0,6
dimension tolerances apply
before paint

P2

A1; A2; A3:

A1	R ∞	3/8(1,5)	5/10 × 0,01; E0,5	AR coating No. abc
A2	R ∞	3/1(0,3)	5/10 × 0,063; E0,5	mirror coating No. 123
A3	R ∞	3/3(0,4)	5/8 × 0,1; E0,5	AR coating No. abc
material	Company / N-BK7	test volume: 1/10 × 0,04	1/3 × 0,1	
			n_e 1,51872 ±0,001	v_e 63,96 ±0,5%

$\frac{G}{Rq2}$

Ind. acc. ISO 10110; λ = 546,07 nm

Scale 1:1

B1
B4
(0,75)
0,75
$39,5 - 0,2$ 0
$15 +0,2$ 0
$49 - 0,2$ 0
$15 +0,2$ 0
B2
φ38
B3

Test volume
A3
A2
A1
$46,5 - 0,2$ 0
45° ±0°2'
45° ±0°2'

protective paint
black No. xyz

45°
m
14
26,75
φ38

1:2

Figure A.6 — Example of a tabular element drawing with more than two surfaces; horizontally aligned

chamfers 0,2 – 0,6

$\dfrac{G}{\sqrt{Rq2}}\ (\vee)$

test region

B1

B2

30

25

A2

A4

A1

A3

B3

90° ±5''

1:2

Scale 1:1

Ind. acc. ISO 10110; λ = 633 nm

surface A1	surface A2	surface A3	surface A4	material
R ∞	R ∞	R ∞	R ∞	Company / BAL15
3/5(1,0)	3/3(0,6)	3/5(1,0)	3/5(1,0)	n_e 1,55897 ±0,0005
4/–	4/–	4/–	4/–	v_e 58,41 ±0,5%
5/1 × 0,006; C1 × 0,1; L5 × 0,004; E0,06	5/1 × 0,006; C1 × 0,1; L5 × 0,004; E0,06	5/1 × 0,006; C1 × 0,1; L5 × 0,004; E0,06	5/1 × 0,006; C1 × 0,1; L5 × 0,004; E0,06	
	pyr A1A4, A2 < 3'	pyr A1A4, A3 < 3'		0/10
λ CZN2520-CZ219	λ CZN2520-alum	λ CZN2520-alum	λ CZN2520-CZ219	1/10 × 0,010
P2	P2	P2	P2	2/–
test region: 3/2(0,5)				

Figure A.7 — Example of a tabular element drawing with more than two surfaces; vertically aligned

Figure A.8 — Example of a tabular element drawing with more than two surfaces; horizontally aligned

LENS 1   LENS 2

A

B

92

(39,146)

1:5

Indication in accordance with ISO 10110; λ = 546,07 nm   (f' = −472,49)

left surface	to be cemented	right surface
	cement xyz 0,005 ±0,003 1/1 × 0,025	
4/−	4/△0,1'	4/0,1'

Scale 1:1
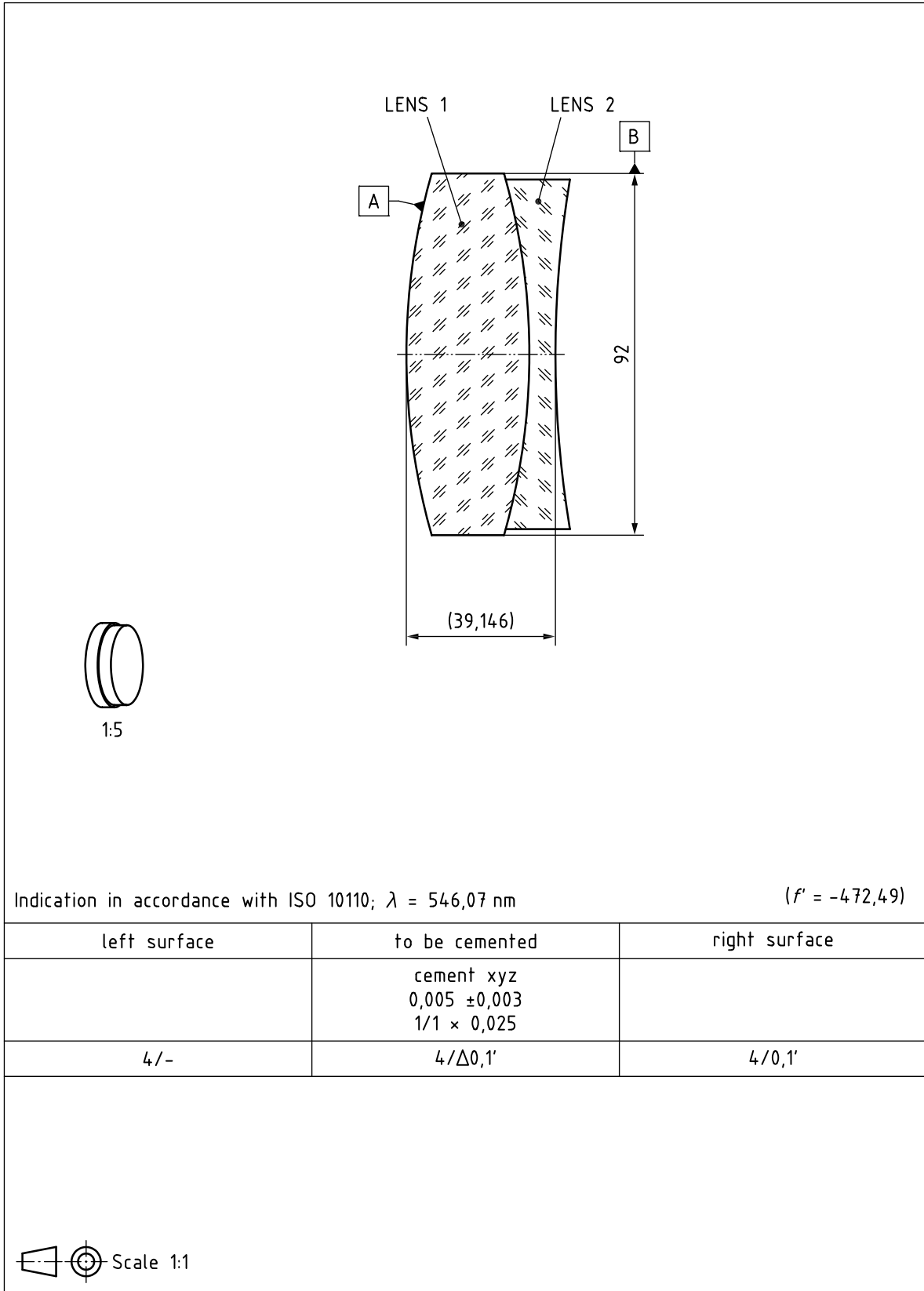
Figure A.9 — Example of tabular indication of data for a cemented assembly (doublet)

Lens L2

B

A

92

Lens L1

Lens L3

(65,632)

1:5

Ind. acc. ISO 10110; λ = 546,07 nm

(f' = +472,49)

L1 part no. 000000-1234-012	L2 part no. 000000-0000-004	L3 part no. 000130-0004-443

to be cemented	to be cemented
1/ 0,005 ±0,003 cement xyz	1/ 0,005 ±0,003 cement abc

Scale 1:1
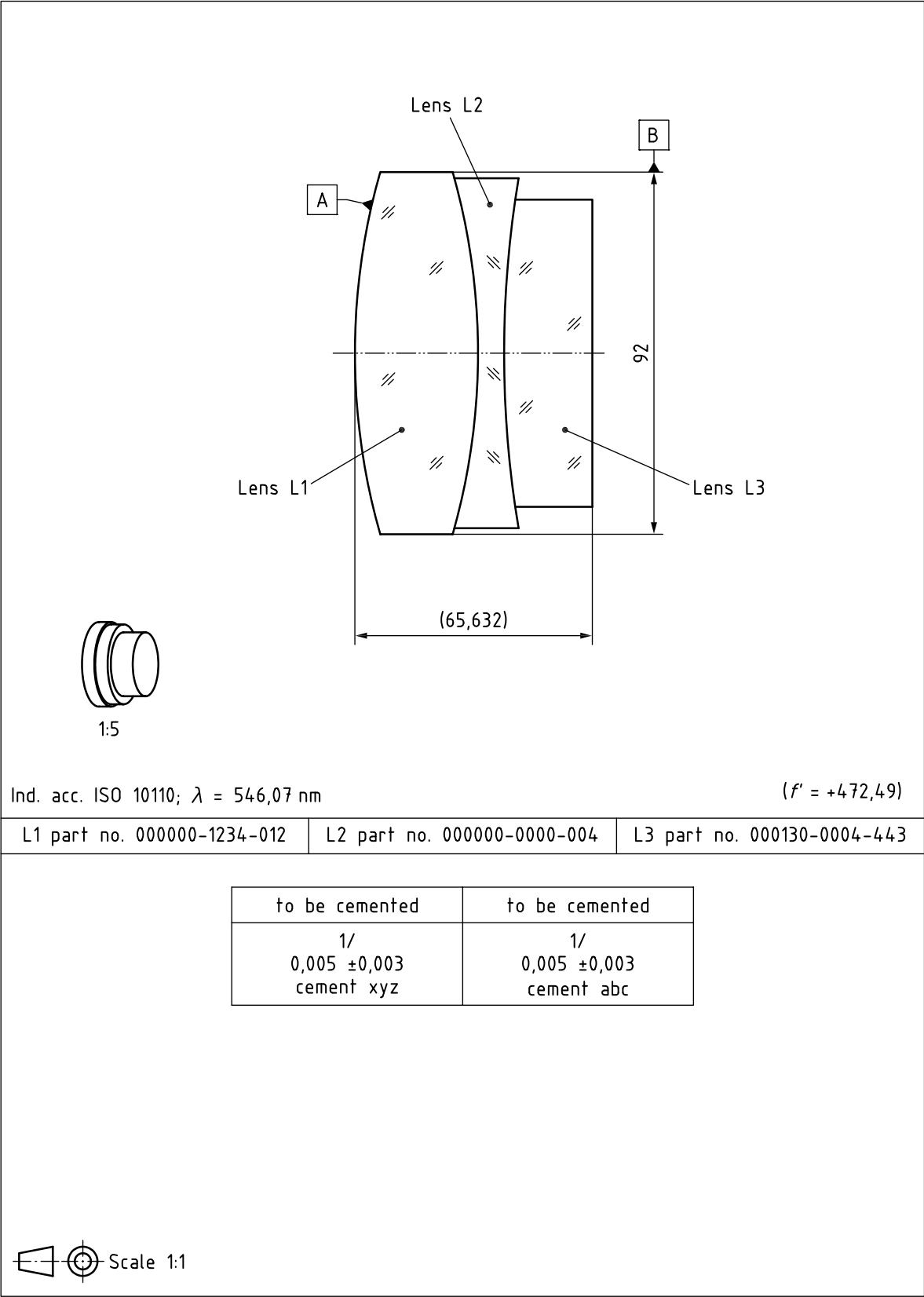
Figure A.10 — Example of tabular indication of data for a cemented assembly (triplet)

Ind. acc. ISO 10110; λ = 546,07 nm

(f' = 80,97 ±0,15)

Surface 1	Material	Surface 2	Surface 3	Material	Surface 4
R 51,43 CX	Company / N–BK7	R 29,0 CX	R 29,0 CC	Company / N–F2	R 99,18 CX
ϕ_e 17	n_d 1,517 ±0,001	ϕ_e 16,5	ϕ_e 16,5	n_d 1,620 ±0,001	ϕ_e 17
Protective Chamfer 0,4 to 0,6	v_d 64,2 ±1%	Protective Chamfer 0,4 to 0,6	Protective Chamfer 0,4 to 0,6	v_d 36,4 ±1%	Protective Chamfer 0,4 to 0,6
	0/20			0/20	
	1/5 × 0,1			1/5 × 0,1	
3/2(0,5)		3/2(0,5)	3/2(0,5)		3/2(0,5)
4/2'		4/Δ1'			4/0,8'
	2/1;2			2/1;2	
5/5 × 0,4; L2 × 0,02		5/5 × 0,4; L2 × 0,02	5/5 × 0,4; L2 × 0,02		5/5 × 0,4; L2 × 0,02
6/–		6/–	6/–		6/–
		Cement: PQR123			
Scale: 3:1					

Figure A.11 — Example of tabular indication of data for the cemented assembly, when no detail element drawings are used; fully tabulated

Figure A.12 — Example of tabular indication of data for the cemented assembly, when no detail element drawings are used; partially tabulated

Surface 1	Surface 2	Surface 3	Surface 4
P3	P3	P3	P3
R 96,38 CX	R 132,6 CX	R 132,6 CC	R 275,0 CX
ϕ_e 42,0	ϕ_e 41,5	ϕ_e 41,5	ϕ_e 42
Protective chamfer 0,2 – 0,4	Protective chamfer 0,1 – 0,2	Protective chamfer 0,1 – 0,2	Protective chamfer 0,2 – 0,4
(λ) AR coating 400nm – 700nm, p < 1%	(λ) –	(λ) –	(λ) AR coating 400nm – 700nm, p < 1%
3/3(0,5)	3/3(0,5)	3/3(0,5)	3/3(0,5)
4/2' AB	4/Δ 30"	4/ 1' AB	4/ –
5/10 × 0,16; L5 × 0,025	5/10 × 0,16; L5 × 0,025	5/10 × 0,16; L5 × 0,025	5/10 × 0,16; L5 × 0,025
6/–	6/–	6/–	6/–
	Cement: PQR123 – Bubbles or inclusions are not allowed		

		Scale: 1:1	Code:
Indications in accordance with ISO 10110		Date: 2012.08.20	Name:

39

AR 209,1060

A

G / Rq2   B

R37,449

P2

λ   λ

R∞

$\phi_e 30,5$

$\phi 33h8$

P2

3/5(1)
4/1,4'
5/5 × 0,1; C5 × 0,16;
  L3 × 0,004; E0,4
6/6 kWcm^{-2}; 1064 nm; 20 ns

6 ±0,1

0/20
1/5 × 0,1
2/1; 2

3/5(1)
5/5 × 0,1; C5 × 0,16;
  L3 × 0,004; E0,4
6/6 kWcm^{-2}; 1064 nm; 20 ns

1:2

Ind. acc. ISO 10110; λ = 546,07 nm

$(f' = 57,24)$

Material:
Company 1 / LaC9 or
Company 2 / LaK9
n(1064 nm) = 1,6759 ±0,001

Scale 1:1

Protective chamfers: 0,2 – 0,6

Figure A.13 — Example of a lens element drawing in the alternative layout

Figure A.14 — Example of a lens element drawing in the alternative layout

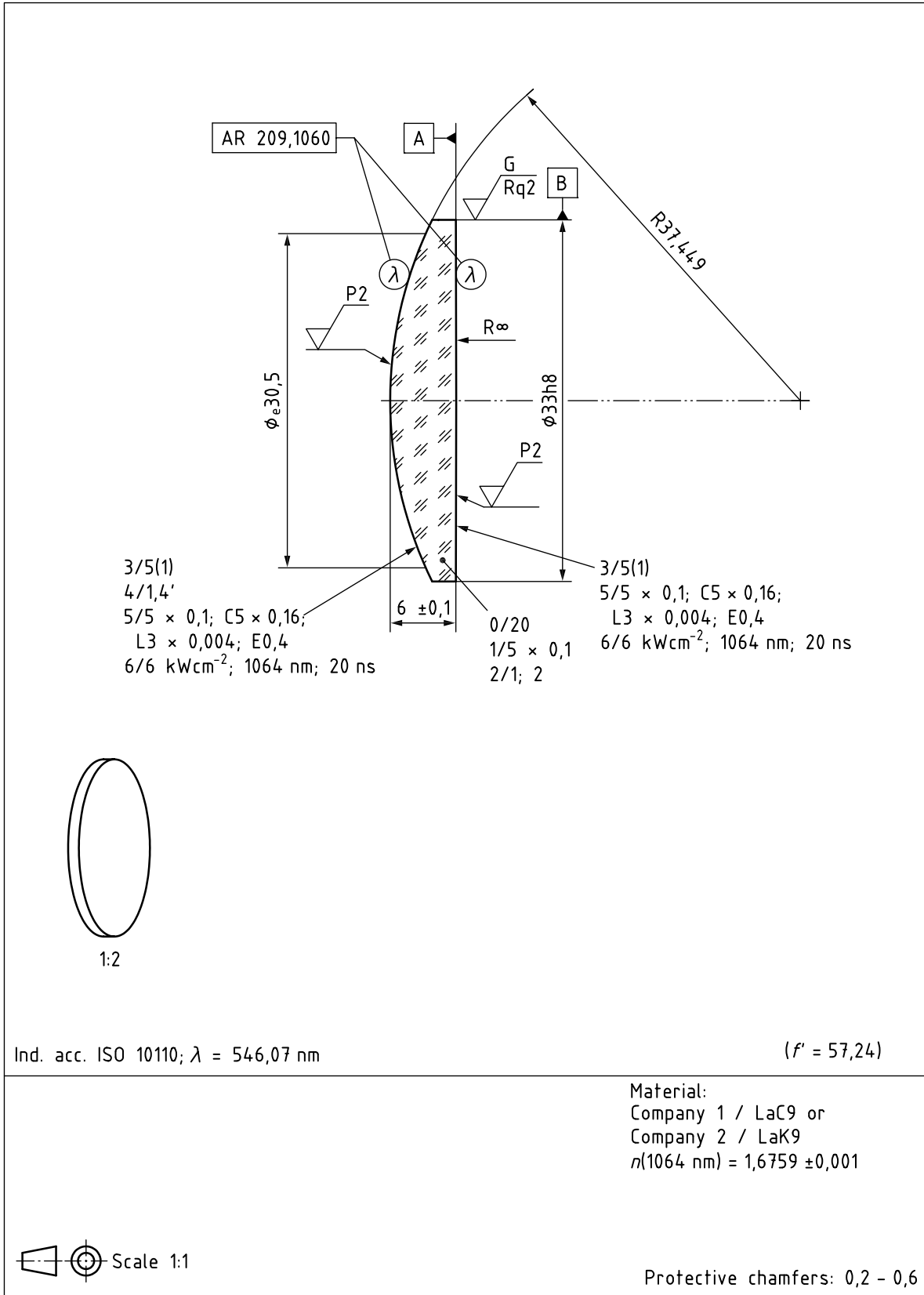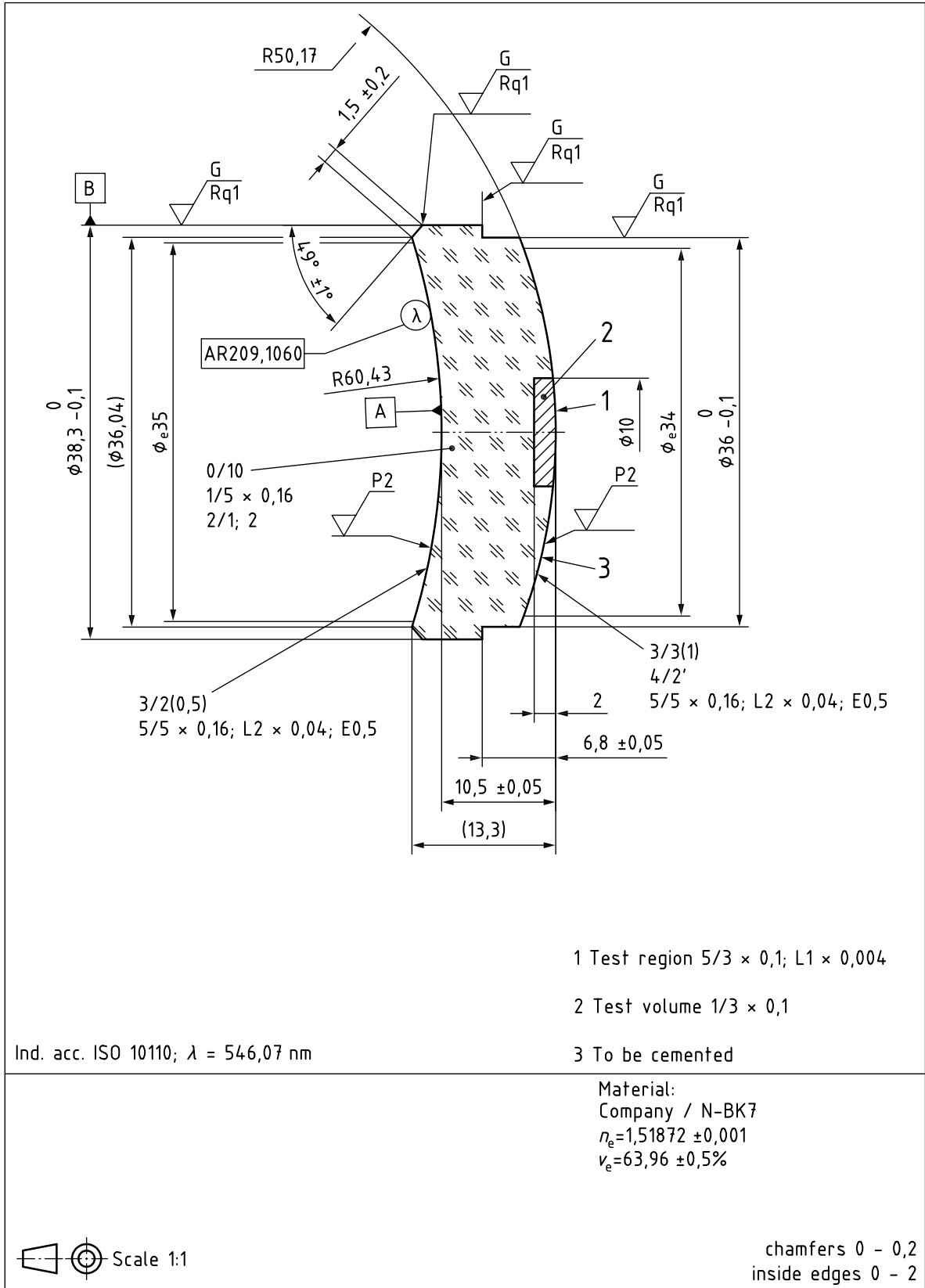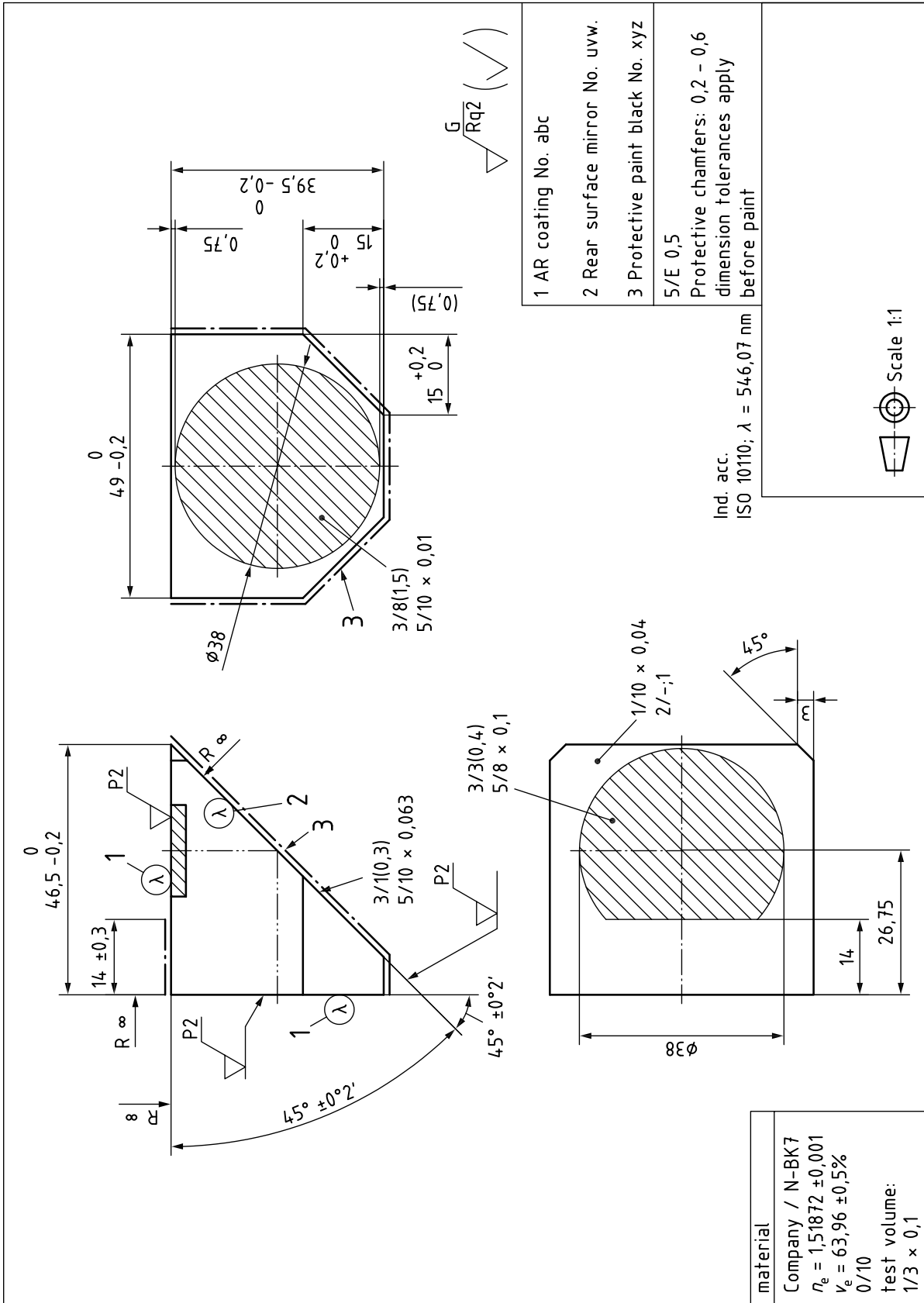**Figure A.15 — Example of a lens element drawing in the alternative layout**
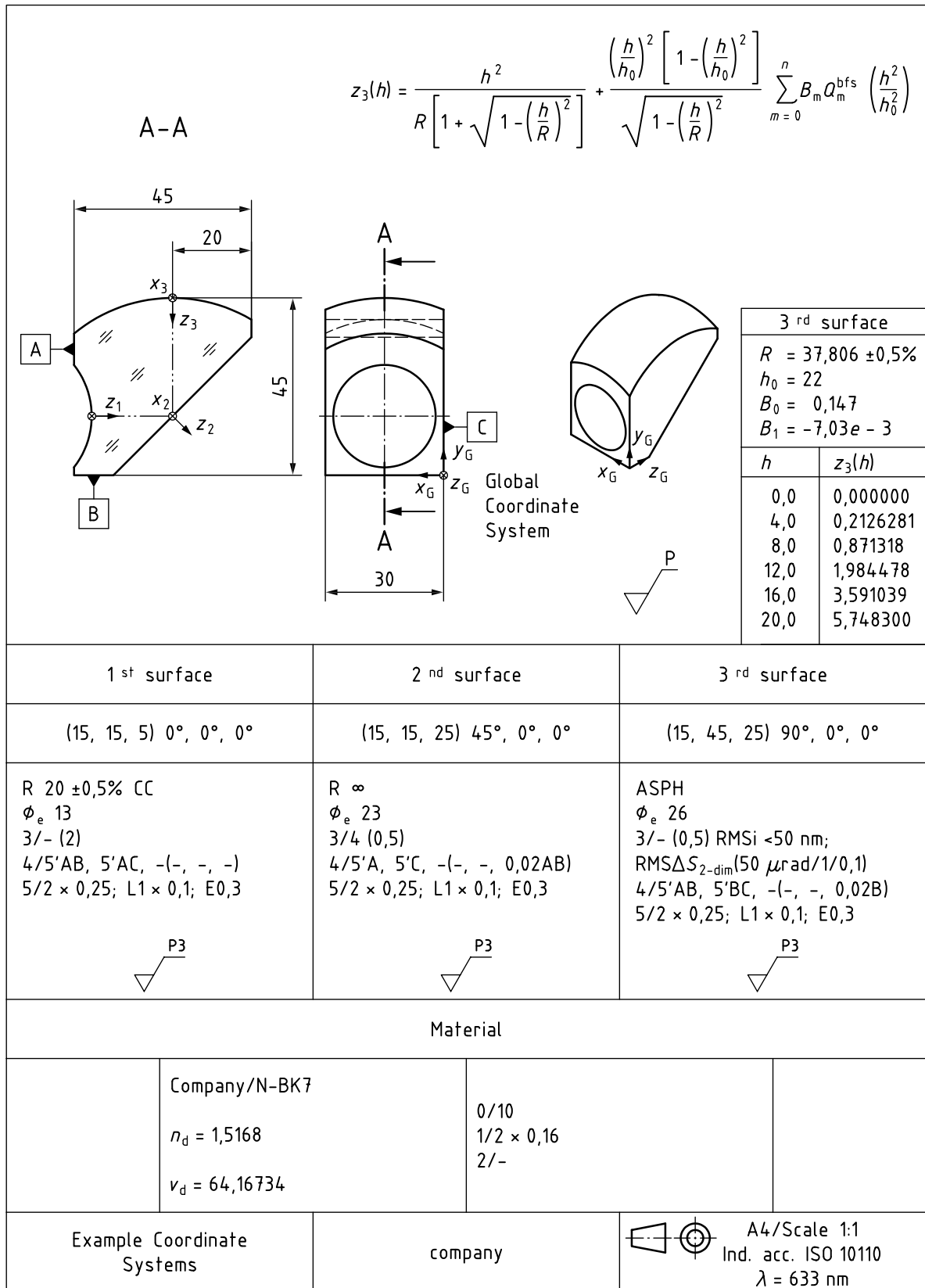
$$z_3(h) = \frac{h^2}{R\left[1 + \sqrt{1 - \left(\frac{h}{R}\right)^2}\right]} + \frac{\left(\frac{h}{h_0}\right)^2\left[1 - \left(\frac{h}{h_0}\right)^2\right]}{\sqrt{1 - \left(\frac{h}{R}\right)^2}} \sum_{m=0}^{n} B_m Q_m^{bfs}\left(\frac{h^2}{h_0^2}\right)$$

3 rd surface

R	= 37,806 ±0,5%
h_0	= 22
B_0	= 0,147
B_1	= -7,03e - 3

h	$z_3(h)$
0,0	0,000000
4,0	0,2126281
8,0	0,871318
12,0	1,984478
16,0	3,591039
20,0	5,748300

1 st surface	2 nd surface	3 rd surface
(15, 15, 5) 0°, 0°, 0°	(15, 15, 25) 45°, 0°, 0°	(15, 45, 25) 90°, 0°, 0°
R 20 ±0,5% CC ϕ_e 13 3/- (2) 4/5′AB, 5′AC, -(-, -, -) 5/2 × 0,25; L1 × 0,1; E0,3	R ∞ ϕ_e 23 3/4 (0,5) 4/5′A, 5′C, -(-, -, 0,02AB) 5/2 × 0,25; L1 × 0,1; E0,3	ASPH ϕ_e 26 3/- (0,5) RMSi <50 nm; RMS$\Delta S_{2\text{-dim}}$(50 μrad/1/0,1) 4/5′AB, 5′BC, -(-, -, 0,02B) 5/2 × 0,25; L1 × 0,1; E0,3

Material

	Company/N–BK7	0/10	
	n_d = 1,5168	1/2 × 0,16	
	v_d = 64,16734	2/-	

| Example Coordinate Systems | company | A4/Scale 1:1
Ind. acc. ISO 10110
λ = 633 nm |

Figure A.16 — Example of an optical prism with local coordinate systems

$$r^2 = x^2 + y^2$$

$$z_{asp}(r) = \frac{r^2}{R \cdot \left(1 + \sqrt{1 - (1+k) \cdot \dfrac{r^2}{R^2}}\right)} + \sum_{i=2}^{n} A_{2i} \cdot r^{2i}$$

1st surface
$R = 20 \pm 0,001$
$k = -1$
$A_6 = -3,456\,E{-}007$
$A_8 = 1,234\,E{-}010$
$A_{10} = -2,345\,E{-}013$

$$z_{sum}(r) = z_{sp}(r) + z_{DOE}(r)$$

$$z_{DOE}(r) = T \cdot [N(r) - \text{sign}(N(r)) \cdot \text{Integer}(\lVert N(r)\rVert)]$$

$$N(r) = \frac{M}{2\vartheta} \cdot \sum_{i=0}^{8} C_{2i} \left(\frac{r}{r_0}\right)^{2i}$$

3rd surface

Sphere	DOE
$R = 20$	$T = 1,56\,\mu m$; $r_0 = 22,5$; $M = 1$; $C_2 = 1,47328$; 6 zones

Diagram: $\phi25\,^{+0,02}_{-0,04}$; markings 1st, 2nd, 3rd, 4th; G Rq 2; axes z, y, x.

1st surface	Material Specification	2nd surface	Material Specification	3rd surface	Material Specification	4th surface
(0, 0, 0) 0°, 0°, 0°	company/N – BK7	(0, 0, 11) 0°, 0°, 0°	PMMA	(0, 0, 11,2) 0°, 0°, 0°	SiO$_2$	(0, 0, 11,4) 0°, 0°, 0°
ASPH	$n_d = 1,5168$	R20 ±0,002 CX	$n_d = 1,4913$	Sphere + DOE	$n_d = 1,4585$	R20 ±0,002 CX
ϕ_e 22,5	$v_d = 64,167$	ϕ_e 22,5	$v_d = 57,385$	R20 ±0,001 CX	$v_d = 67,82$	ϕ_e 22,5
Prot. Chamfer 0,3 – 0,5		No Prot. Chamfer		ϕ_e 22,5		Prot. Chamfer 0,3 – 0,5
				No Prot. Chamfer		
3/- (1) RMSi < 50 nm;	0/10	3/- (0,7)	0/10	3/- (1)	0/10	3/- (2)
$\Delta S_{2\text{-dim}}(80\,\mu rad/1/0,1)$;	1/8 × 0,16	1/2 × 0,16	1/2 × 0,16	full surface non-contact	1/1 × 0,16	
RMS$\Delta S_{2\text{-dim}}(25\,\mu rad/1/0,1)$;	2/-	2/-	2/-	measurement	2/-	
full surface non-contact				transition area <20 μm		
measurement						
4/-		4/1'A,–,–		4/2'A,–,–		4/2'A,–,–
		(–,–, 0,1A)		(0,02,–, 0,005A)		(–,–, 0,003A)
5/8 × 0,1; L2 × 0,01		5/6 × 0,1;L2 × 0,01		5/12 × 0,063		5/12 × 0,063
λ AR R_{max} <0,5 %						λ AR R_{max} <0,5 %
@ 400nm – 700nm						@ 400nm – 700nm
P3 0,002–1/Rq 0,002		P3 0,002–1/Rq 0,001		P2		P3 0,002–1/Rq 0,002

Example for Multi-Surface Drawing	Ind. acc. ISO 10110	21.09.2015
Size A4	λ = 546 nm	
Page 1 of 1	Scale 2:1	

Figure A.17 — Example of a multi-surface element with local coordinates

Bibliography

[1]   ISO 1, *Geometrical product specifications (GPS) — Standard reference temperature for the specification of geometrical and dimensional properties*

[2]   ISO 128-20, *Technical drawings — General principles of presentation — Part 20: Basic conventions for lines*

[3]   ISO 128-24, *Technical drawings — General principles of presentation — Part 24: Lines on mechanical engineering drawings*

[4]   ISO 128-30, *Technical drawings — General principles of presentation — Part 30: Basic conventions for views*

[5]   ISO 128-50, *Technical drawings — General principles of presentation — Part 50: Basic conventions for representing areas on cuts and sections*

[6]   ISO 129 (all parts), *Technical drawings — Indication of dimensions and tolerances*

[7]   ISO 10110-5, *Optics and photonics — Preparation of drawings for optical elements and systems — Part 5: Surface form tolerances*

[8]   ISO 10110-7, *Optics and photonics — Preparation of drawings for optical elements and systems — Part 7: Surface imperfections*

[9]   ISO 10110-8, *Optics and photonics — Preparation of drawings for optical elements and systems — Part 8: Surface texture; roughness and waviness*

[10]   ISO 10110-9, *Optics and photonics — Preparation of drawings for optical elements and systems — Part 9: Surface treatment and coating*

[11]   ISO 10110-14, *Optics and photonics — Preparation of drawings for optical elements and systems — Part 14: Wavefront deformation tolerance*

[12]   ISO 10110-17, *Optics and photonics — Preparation of drawings for optical elements and systems — Part 17: Laser irradiation damage threshold*

[13]   ISO 13715, *Technical product documentation — Edges of undefined shape — Indication and dimensioning*

[14]   ISO 14405-1, *Geometrical product specifications (GPS) — Dimensional tolerancing — Part 1: Linear sizes*

[15]   ISO 14405-2, *Geometrical product specifications (GPS) — Dimensional tolerancing — Part 2: Dimensions other than linear or angular sizes*

[16]   IEC 60758:2016, *Synthetic quartz crystal — Specifications and guidelines for use*

[17]   ISO 7944, *Optics and optical instruments — Reference wavelengths*

In this adopted standard, references appear to certain International Standards for which Indian Standards also exist. The corresponding Indian Standards, which are to be substituted in their respective places, are listed below along with their degrees of equivalence for the editions indicated:

International Standard	Corresponding Indian Standard	Degree of Equivalence
ISO 128-24 Technical drawings — General principles of presentation — Part 24: Lines on mechanical engineering drawings	IS 10714 (Part 2) : 2023/ ISO 128-2 : 2022 Technical product documentation (TPD) — General principles of representation: Part 2 Basic conventions for lines	Identical
ISO 10110-6 Optics and photonics — Preparation of drawings for optical elements and systems — Part 6: Centring tolerances	IS 5920 (Part 3) : 2024/ ISO 10110-6 : 2015 Optics and photonics — Preparation of drawings for optical elements and systems: Part 6 Centring tolerances	Identical
ISO 10110-11 Optics and photonics — Preparation of drawings for optical elements and systems — Part 11: Non-toleranced data	IS 5920 (Part 7) : 2024/ ISO 10110-11 : 2016 Optics and photonics — Preparation of drawings for optical elements and systems: Part 11 Non-toleranced data	Identical
ISO 10110-12 Optics and photonics — Preparation of drawings for optical elements and systems — Part 12: Aspheric surfaces	IS 5920 (Part 8) : 2024/ ISO 10110-12 : 2019 Optics and photonics — Preparation of drawings for optical elements and systems: Part 12 Aspheric surfaces	Identical
ISO 10110-18 Optics and photonics — Preparation of drawings for optical elements and systems — Part 18: Stress birefringence, bubbles and inclusions, homogeneity, and striae	IS 5920 (Part 12) : 2024/ ISO 10110-18 : 2018 Optics and photonics — Preparation of drawings for optical elements and systems: Part 18 Stress birefringence, bubbles and inclusions, homogeneity, and striae	Identical
ISO 10110-19 Optics and photonics — Preparation of drawings for optical elements and systems — Part 19: General description of surfaces and components	IS 5920 (Part 13) : 2024/ISO 10110-19 : 2015 Optics and photonics — Preparation of drawings for optical elements and systems: Part 19 General description of surfaces and components	Identical
ISO 12123 Optics and photonics — Specification of raw optical glass	PGD 39 (24214)/ISO 12123 : 2018 Optics and photonics — Raw optical glass — Specification	Identical
ISO 80000-1 Quantities and units — Part 1: General	IS/ISO 80000-1 : 2009 Quantities and units: Part 1 General	Identical

Amendments Issued Since Publication

Amend No.	Date of Issue	Text Affected