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Optomechanical Drawings: ISO 10110 Standard

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Drawing Standards

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- Two commonly used standards
  - International Standards Organization (ISO)
  - American National Standards Institute (ANSI)
    - American Society of Mechanical Engineers (ASME) is now responsible for updating & maintaining these standards

- These standards explain how to indicate/callout the desired features on a drawing for a finished product

- The values of these desired features are not specified by these standards

- ISO standards are fairly commonly used in optical industry and shops

Optical Drawing Standards

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- The two standards that are of greatest interest are:
  - ISO 10110-X-1996 (E) - *Optics and optical Instruments - Preparation of optical drawings for optical elements and systems*
  - ISO 9211 - *Optical coatings*

- ISO 10110 is similar to ASME Y14.18M. There is no American standard equivalent to ISO 9211

- ISO 10110 has 13 parts:

  - Part 1 General
    - Covers the mechanical aspects of optical drawings that are specific to optics and not already covered in one of the other ISO drawing standards.

ISO 10110 Standard

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- Part 2 Material Imperfections - Stress birefringence
- Part 3 Material Imperfections - Bubbles and Inclusions
- Part 4 Material Imperfections - Inhomogeneity and striae
  - Parts 2-4 cover material related parameters controlling the quality of glass
- Part 5 Surface form tolerances
  - Concerns figure measurement and differentiates between figure measured visually with a test plate or with a phase measuring interferometer
- Part 6 Centering tolerances
  - Deals with centering errors and allows either an entirely mechanical method of tolerancing or an optomechanical one.

ISO 10110 Standard

- Part 7 Surface imperfection tolerances
  - This is equivalent to scratch and dig or surface beauty specification
- Part 8 Surface texture
  - Concerns ground and polished surface texture and is unique to this standard
- Part 9 Surface treatment and coating
  - Tells how to indicate that a surface will be coated, but not what the specifications of the coating are which is covered in ISO 9211.
- Part 10 Table representing data of a lens element
  - Tells how to describe the parameters of an optical element in tabular form
  - It is the foundation of the effort to simplify transfer of data about optical elements electronically

ISO 10110 Standard

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- Part 11 Non- toleranced data
  - Table of default tolerances on optical parameters
  - If a particular parameter is not specified, it should then be made to the tolerances given in this table
- Part 12 Aspheric surfaces
  - Defines how to describe an aspheric surface.
  - This method has been coordinated with the major vendors of lens design software so the definitions are consistent
- Part 13 Laser irradiation damage threshold
  - Tells how to specify a laser power damage threshold on an optical component

ISO Standard Drawing Table

Table field
Indications in accordance with 3.2

Left surface	Material specification	Right surface
R		R
$\varnothing_e$		$\varnothing_e$
Protective chamfer	n	Protective chamfer
λ	ν	λ
3/	0/	3/
4/	1/	4/
5/	2/	5/
6/*		6/*
To be cemented*		To be cemented*
Indications in accordance with ISO 10110	*Title field* *Indications in accordance with 3.3*	

(if required)

Figure 1 — Tabular indication of data for a lens element

Example of Lens Drawing

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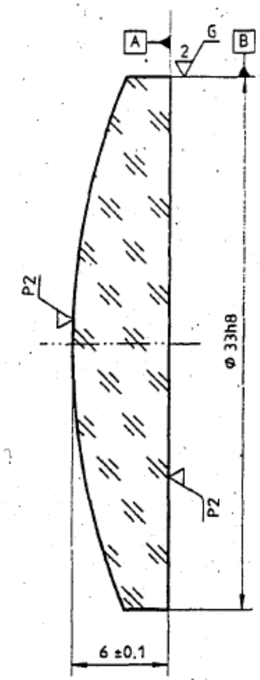

Left surface	Material specification	Right surface
R 37,449 CX Ø$_e$ 30,5 Protective chamfer 0,4 – 0,6 (λ) AR 209.1060 3/ 5(1) 4/ 1,4′ 5/ 5 × 0,1; C 5 × 0,16; L 3 × 0,004; E 0,4 6/ 6 KWcm^{-2}; 1 060 nm; 10	Hoya LaC9 or Schott LaK9 n (1 060 nm) 1,675 9 ± 0,001 ν — 0/ 20 1/ 5 × 0,1 2/ 1; 2	*R* ∞ Ø$_e$ 29 Protective chamfer 0,4 – 0,6 (λ) AR 209.1060 3/ 5(1) 4/ — 5/ 5 × 0,1; C 5 × 0,16; L 3 × 0,004; E 0,4 6/ 6 KWcm^{-2}; 1 060 nm; 10
Indications in accordance with ISO 10110	Lens 114.379	

Figure 2 — Example of tabular indication of data for a lens element

Advantages of ISO Standards

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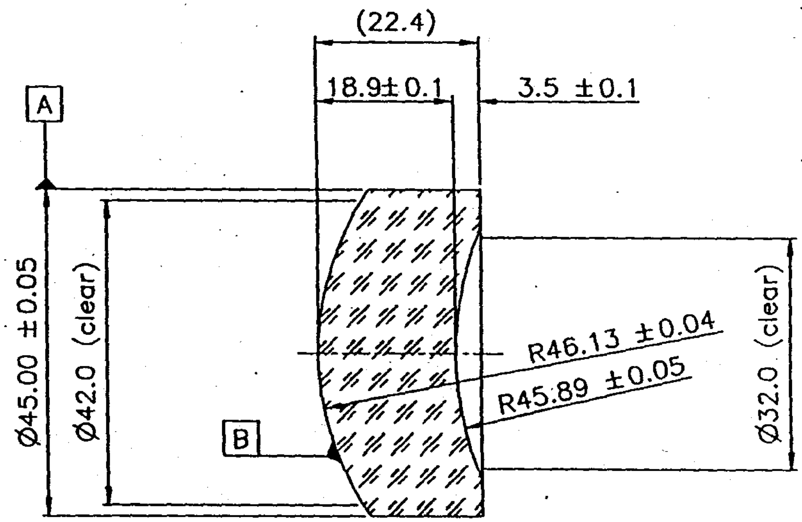
- Offer guidance on suggested values of certain features
- Contain a listing of default tolerances
- Much more thorough in their treatment of drawing features
- Being integrated in optical design software
- Drawings created using ISO standards are virtually noteless
- Indications on drawings use alphanumeric symbols
- Drawing can be interpreted by persons having any language background without having to translate it

LENS DRAWING

- For lens drawing a full section view is normally sufficient to display all physical sizes of the lens. If there are unusual truncations then extra views may be added to display them.
- Dimension in accordance with standard drawing practices.
- RADIUS
  - radius should be dimensioned with an arrow coming from the center of curvature. If the radius is flat, then the radius may be marked as to whether it is concave or convex. Sometimes the radius is provided in a table, then it will also be labelled convex or concave.
  - Marking convex or cancave can be done using short forms CV and CX. In some cases the use of + and − signs may be used, but there should be a reference guide to interpret this on the drawing as this can be confusing.
  - A flat polished surface should be marked as having a radius of INFINITY
  - ASPHERE or BINARY ASPHERE will be defined by a note, with a reference note triangle pointing to the specific surface.
  - CYLINDER surface will specifically note that the surface is cylindrical along with the cylinder radius.
- CLEAR APERTURE
  - the clear aperture is the region of the polished polished surface through which the normal path of 'light' will travel.
  - this will be dimensioned and noted that it is the 'clear aperture' or 'free diameter'. It may also appear in a table on the drawing.
- DATUMS
  - datums indicate the reference surfaces for tolerancing wedge, and surface runouts relative to. They are indicated by either of the following two symbols:

$\boxed{A}$ $\boxed{B}$ or $\boxed{-A-}$ $\boxed{-B-}$

(ISO 10110)

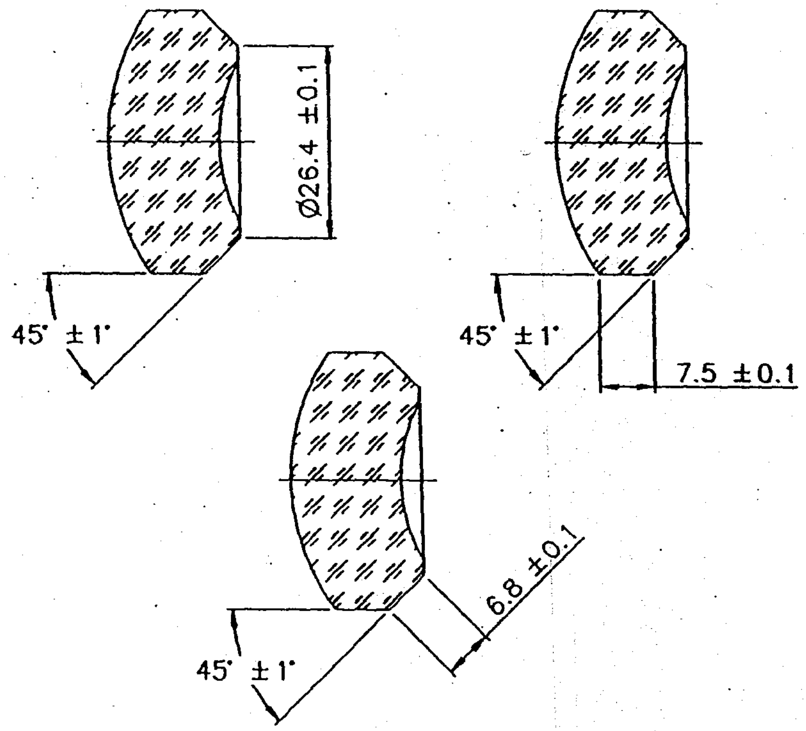


CHAMFERS

DEFINITION
–a chamfer is a ground surface cut at an angle, usually to prevent edge chips. It may also be used for mechanical mounting or clearances. If it is to protect against edge chips it is called a PROTECTION CHAMFER.

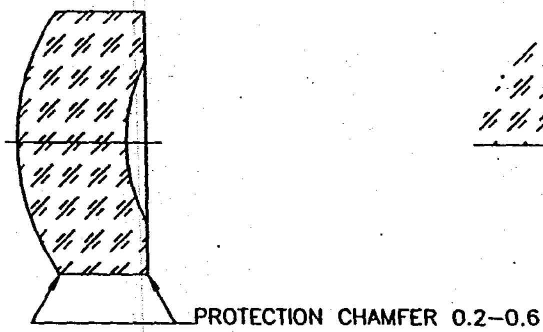
CHAMFER / BEVEL
–normal chamfers and bevels should be dimensionsed with a dimension and an angle.

examples:

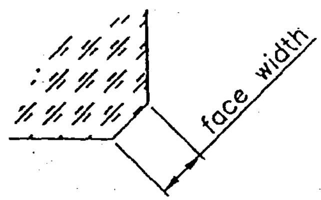


PROTECTION CHAMFER
–a protective chamfer shall be described as a note in the general notes section, or on the drawing pointing to the specific surfaces to be chamfered. The note shall give a maximum and minimum dimension for the chamfer. The values represent the lenght of the chamfer across it's face – 'face width'

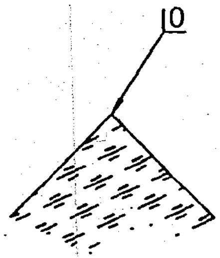
example:



measured this way:



SHARP EDGE
–prisms often require a sharp edge between two polished surfaces. A sharp edge can be noted as follows:



A note may accompany this to indicate the maximum chip size permitted on the edge.

MATERIAL DEFINITION

- The following information must be included on the drawing:
  - MATERIAL
  - tolerance on REFRACTIVE INDEX
  - tolerance on DISPERSION
- The following information may be included on the drawing:
  - alternate materials
  - BUBBLES and INCLUSIONS
  - HOMOGENEITY
  - STRAIE
- This information can be located in any of several locations on a drawing. The information may be included in the 'MATERIAL' block of the drawing title block, or in the 'BILL OF MATERIAL' block, or in the notes. Present practice at Elcan is to include it in the notes, with a reference to the note in the material block.

<u>MATERIAL</u>

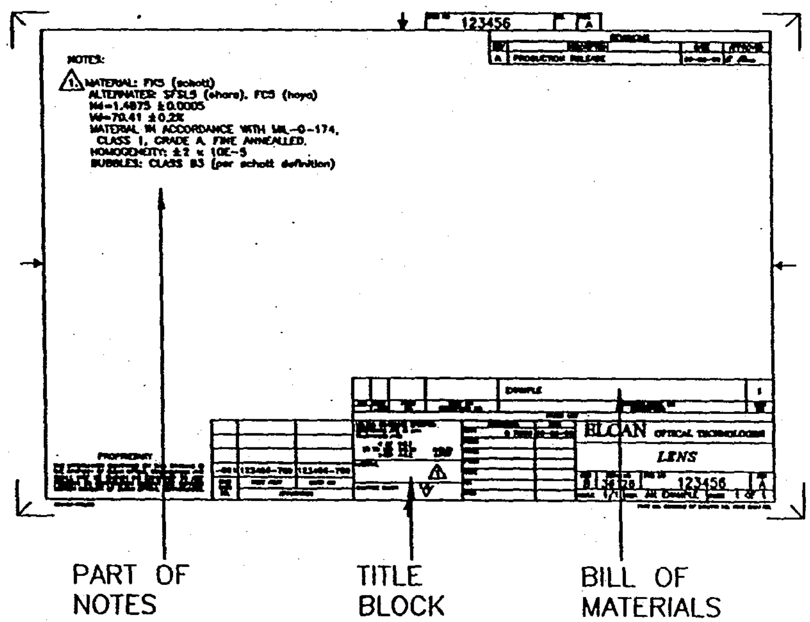
- material is called up by the manufacturers code or by the 6 digit code
  ie: BK7 (schott) or 517642
- the first 3 digits of the code represent the refraction index, while the last 3 digits represent the dispersion
  ie: BK7 refractive index is 1.<u>517</u> and the dispersion is <u>64.2</u> so it's 6 digit code is 517642

<u>REFRACTIVE INDEX</u>

- The ratio of the velocity of light in a vacuum to the velocity of light in the refracting material. This defines how the light 'bends' going into the glass.
- normally defined at wavelenght of 587 nm.
- typical format: Nd= 1.5168 ±0.0005

<u>DISPERSION</u> (Abbe number)

- defines the ratio of refractive index for different wavebands. A low value indicates more rainbow effect on light through a prism
- typical format: Vd-64.2 ±0.8%



<u>A TYPICAL MATERIAL CALLOUT NOTE:</u>

NOTES:

△1. MATERIAL: FK5 (schott)
ALTERNATES: SFSL5 (ohara), FC5 (hoya)
Nd=1.4875 ±0.0005
Vd=70.41 ±0.2%
MATERIAL IN ACCORDANCE WITH MIL-G-174, CLASS 1, GRADE A, FINE ANNEALLED.
HOMOGENEITY: ±2 x 10E-5
BUBBLES: CLASS B3 (per schott definition)

1/ MATERIAL DEFINITION 2/

BUBBLES AND INCLUSIONS

- bubbles are gaseous bulk material defects which occur in the glass as a result of the manufacturing process. Inclusions covers other types of local defects. ie:crystals, small stnes, sand.
- can be defined by the suppliers class callout per catalog, by ISO 10110 callout, or by MIL-G-174 inclusion callout
- suppliers definition: total cross section of all bubbles and inclusions per cubic volume of material. This would be called out in the material note. Sample definition - SCHOTT

Bubble class	total cross section of all bubbles/inclusions >0.05 mm in mm^2 per 100 cm^2 glass
B0	<0.03
B1	>0.03 TO 0.10
B2	>0.10 TO 0.25
B3	>0.25 TO 0.50

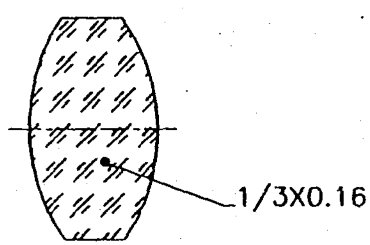
- ISO callout takes the form

1/ N x A

where 1/ is a code to define the callout
N is total number of bubbles and inclusions permitted
A is the grade number which is the square root of the area of the largest permitted bubble or inclusion

(this is more complex than it appears, as the spec allows more bubbles if they are of a smaller size. See ISO 10110 part 3 if needed)

- Form of an ISO callout on dwg:



HOMOGENEITY AND STRAIE

- Homogeneity is the allowable deviation of the refractive index within a piece of glass. (do not confuse this with the tolerance on the refractive index)
- Straie are locally limited areas of inhomogeneity that are optically visible due to a different refractive index than the basic glass
- Homogeneity can be called out several ways on optical drawings.
  1. as a note by specifying the actual homogeneity permitted

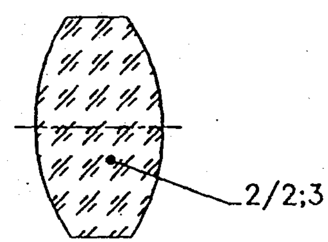
     ie: HOMOGENEITY 5x10E-5
  2. as a note by specifying the manufacturers class designation

     ie: HOMOGENEITY H2 per SCHOTT DEFINITION
  3. by the ISO callout on the drawing taking the form

     2/A;B

     where 2/ is a code to define the callout
     A is the homogeneity class
     B is the straie class
- Straie can be called out in several ways on optical drawings
  1. in the material note by specifying the grade in accordance with MIL-G-174
  2. by the ISO callout on the drawing taking the form

     2/A;B (see above)
- (for details of classes and grades of homogeneity and straie see MIL-G-174 para 3.3.8, or ISO 10110 part 4)
- Form of an ISO callout on dwg:



SURFACE FORM 3/

DEFINITION

–Surface form is the deviation between the optical surface under test, and the nominal theoretical surface, measured perpendicular to the surface.

MEASUREMENT

–Surface form deviation is measured in fringe spacing. One fringe spacing is equal to a distance of 1/2 of the test wavelength.

TYPES OF FORM ERROR

–there are 3 forms of error
- –Power error
- –Irregularity
- –Rotationally symetric irregularity

POWER ERROR

–also called spherical error or sagitta error

–This is error caused by the test surface having a different radius then specified. It results in circular fringe test patterns

IRREGULARITY

–This error is caused by a the surface deviating from sphericity. Examples are cylindrical deviation, or saddle shaped deviation.

ROTATIONAL SYMETRIC IRREGULARITY

–these are localized deviations, or stepped deviations.

DRAWING CALL OUT

–surface form can be called out on a drawing in one of two ways.

–in a table format labelled POWER and IRREGULARITY

–by the ISO callout on the drawing, pointing at the surface of interest with the form 3/A(B) or 3/A(B/C)

where 3/ is a code to define the callout

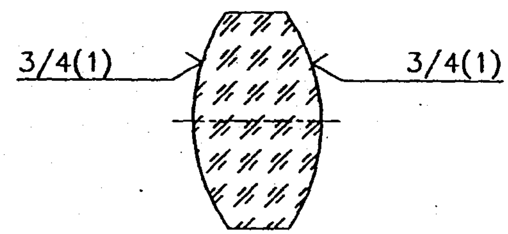
A is the power error

B is the irregularity error

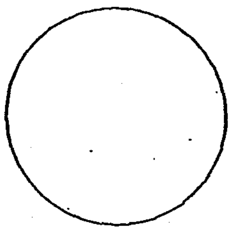
C is the rotationally symetric irregularity.

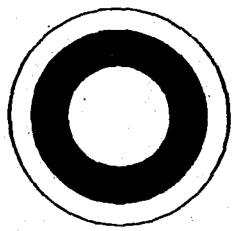
the rotationally symetric error is rarely used on drawings. its value cannot exceed the irregularity error.

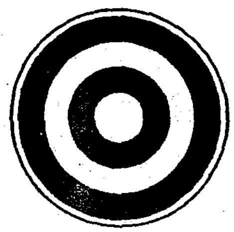
Example of ISO callout



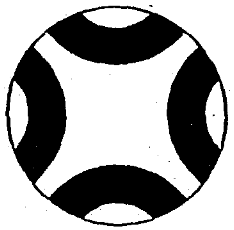
SURFACE FORM 3/


3/0(0)


3/1(0)

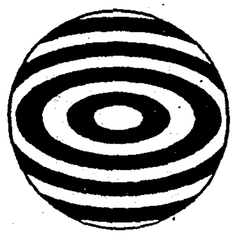

3/2(0)

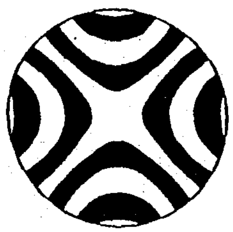

3/3(0)


3/1(2)

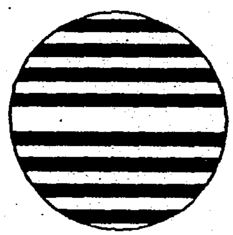

3/2(2)


3/3(2)


3/4(2)


3/2(4)


3/3(4)

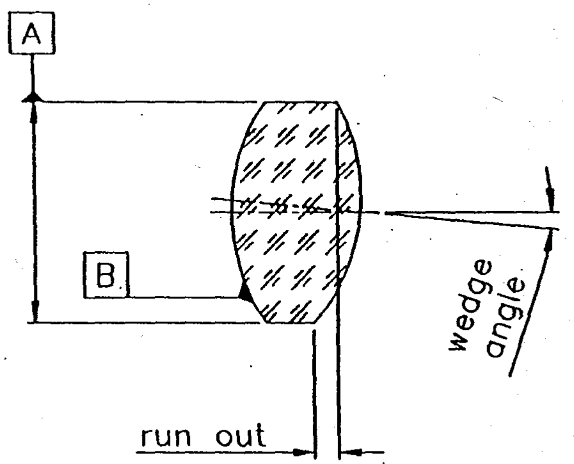

3/4(4)


3/5(4)

CENTERING TOLERANCE 4/

DEFINITION

–Centering error or Wedge error is the tilt of a surface relative to it's datums. The figure below illustrates this



–wedge can be called out as the tilt angle of a surface relative to the other surface, and the cylinder of the lens.

–wedge can also be called out as the change in edge thickness (runout) between the two polished surfaces.

1. ON DOUBLETS, SPECIFY 4/5' A,B. ON THE ELEMENT FAB, AND 4/X' A,B ON THE ASSY. DWG.

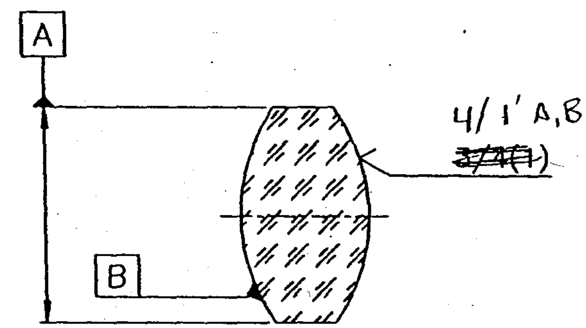
DRAWING CALLOUT

–centering error can be called out on a drawing in one of two ways

–in a table format providing the runout at the edge between the two surfaces labelled as either runout, wedge, TIR, of FIM.
(TIR – total indicator runout)
(FIM – full indiator movement)

–by the ISO callout on the drawing pointing to the surface of interest in the form
4/ X A,B
where 4/ is a code to define the callout
X is the centering error allowable
A,B (optional) are the datums that the centering error is measured from.

Example of ISO callout



SURFACE QUALITY 5/

DEFINITION

–surface quality defines the imperfections permitted on the polished surface. Imperfections can include scratches, pits, broken bubbles, sleeks, scuffs, fixture marks, and coating blemishes.

–surface quality definition in the ISO specification can also control edge chips.

ISO SPECIFICATION

–this spec can get very complicated, and so it is not used very often. It has separate controls on surface imperfections, coating blemishes, long scratches and edge chips. It is defined in ISO 10110, part 7. The call out takes the form of

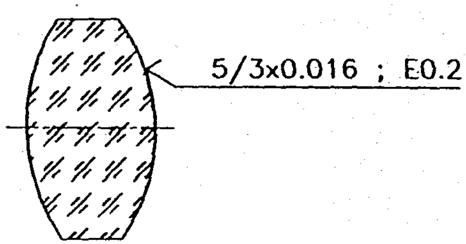
5/N x A ; CN' x A' ; LN'' x A'' ; EA'''

where

- 5/ is a code to define the callout
- N is the number of allowed surface imperfections
- A is the squar root of the surface area of the largest imperfection
- CN' x A' =similar but for coating blemishes only. this is optional
- LN'' x A'' =similar but for long scratches
- EA''' =E is designation for edge chips, and A''' is the extent the chip can be from the edge.

this can be presented without any of the groups.

–below is an example of a ISO designation



MIL SPECIFICATIONS

–there are two military specifications commonly used to define surface quality. For visible optics MIL-PRF-13830 applies. This is usually specified in either the notes, or in a table. It would be specified in the format

SURFACE QUALITY 60–40 PER MIL-PRF-13830

–For infrared optics, or reflecting optics the surface quality is defined by MIL-C-48497. This would also be specified in the notes or in a table. It would be specified in the format

SURFACE QUALITY F-F PER MIL-C-48497

–In both cases above the first value defines the total scratch volume, and the second value defines the total dig volume. The corresponding specs outline the interpretation of these values in more detail.

SURFACE TEXTURE

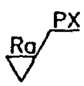
DEFINITION

–Surface texture is the large scale 'roughness' of the surface. This applies to both the polished and the ground surfaces.

POLISHED

–PER ISO 10110

a callout pointing to the surface with a symbol as follows:



where Ra gives RMS surface roughness as follows:

Ra(nm)	description
0.5	very fine
1	fine
2	medium
5	coarse
10	very coarse

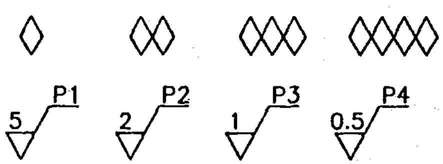
where PX (polishing grade designation) gives number of micro–defects per 10mm of sampling length as follows:

Polish Grade	number of micro defects per 10mm
P1	<400
P2	<80
P3	<16
P4	<3

there are other variations on this which can be found in ISO 10110, part 8

–PER DIN 3140

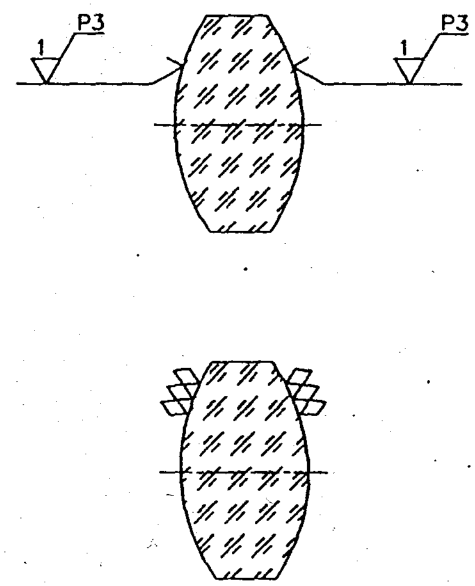
a symbol on the surface represents the surface roughness, and micodefects similar to ISO 10110. The symbol is a diamond pattern, with more diamonds representing a finer polish. DIN 3140 correlates to ISO 10110 as follows:



–OTHER

on many drawings the ISO or DIN specs are not called out. In that case there may be a note specifying the surface roughness in units of (nm) or (angstroms).

–SAMPLES

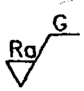


SURFACE TEXTURE

GROUND SURFACE

–PER ISO 10110

a callout pointing to the surface with a symbol as follows:



where Ra gives RMS surface roughness as follows:

Ra(um)	description
0.5	very fine
1	fine
2	medium
5	coarse
10	very coarse

where G represents ground surface

NOTE: units of roughness are different from polished symbols

there are other variations on this which can be found in ISO 10110, part 8

–PER DIN 3140

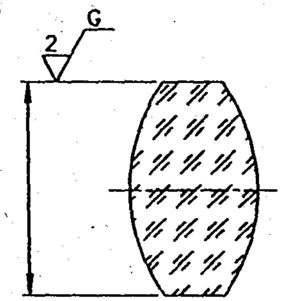
a symbol on the surface represents the surface roughness, similar to ISO 10110.
The symbol is a chevron pattern, with more chevrons representing a finer grind. DIN 3140 correlates to ISO 10110 as follows:

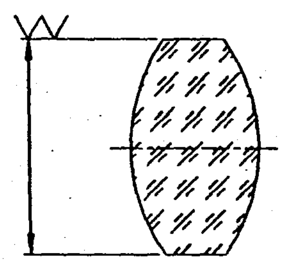
V	coarse, Ra 40 to 20 um
VV	medium, Ra 6 to 4 um
VVV	fine, Ra 3 to 2 um
VVVV	finest, Ra < 2 um

–OTHER

on many drawings the ISO or DIN specs are not called out. In that case there may be a note specifying the surface roughness in units of (nm) or (angstroms). It may also be specified in other terms such as a grit size for the grind compound: ie: 'grind 220 grit'

–SAMPLES



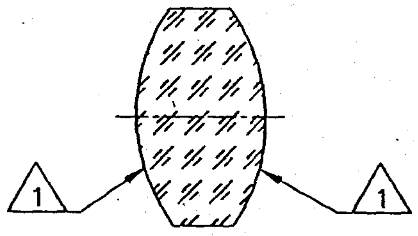


COATING and PAINTING

COATING
- a coating is a thin film of various chemicals applied to an optical surface to do any of the following functions:
  - control reflections
  - provide environmental protection
  - block particular wavebands
  - provide a reflective or partially reflective surface

CALLOUT
- a coating is normally called out with a note, and a referencing note triangle pointing to the specific surface on the drawing.
- see below:

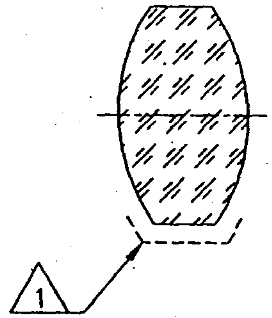
1. COAT INDICATED SURFACE AS FOLLOWS......



PAINTING
- surfaces of optical elements are often painted black outside the useful optical region to cut down on stray light, and to provide an aesthetically pleasing appearance.

CALLOUT
- a painted surface is normally called out with a note, and a referencing note triangle to indicate which surfaces are to be painted on the drawing. The type of paint used will be shown in the Bill of Materials section of the drawing.

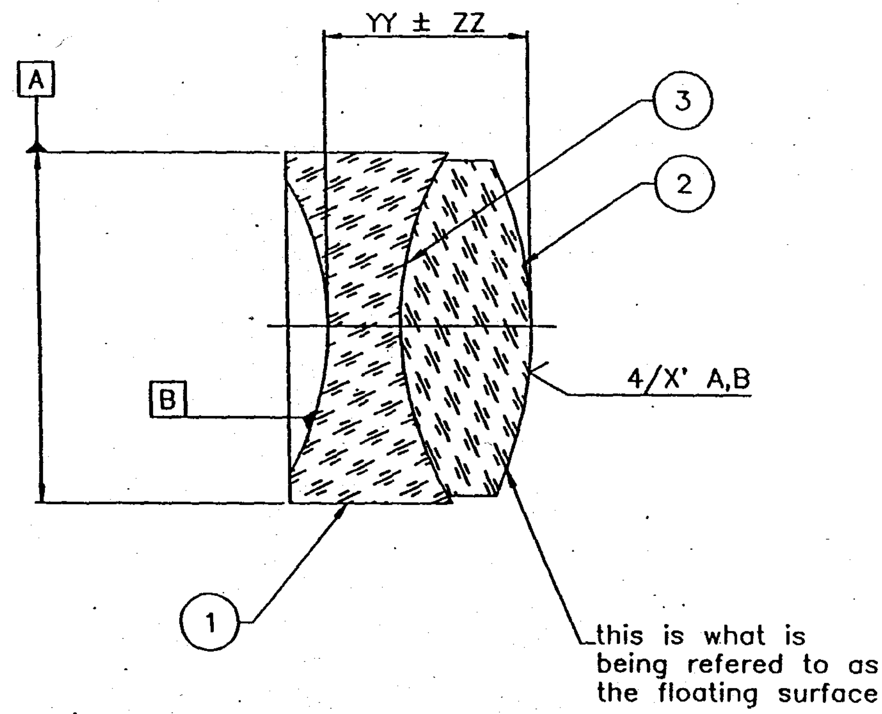
1. PAINT INDICATED SURFACES USING ITEM 1



DOUBLETS

DOUBLET
–a doublet is two optical elements 'bonded' together.

DRAWING INFORMATION
–The drawing will provide the following information
- –BOND MATERIAL – supplied in the bill of materials .
- –ALIGNMENT TOLERANCE – the wedge or runout of the 'floating' element to the primary element's datums
  Wedge is the angle of the 'floating' surface relative to the primary datums. It can be measured as an angle, or a runout parallel to the optical axis
- –OVERALL THICKNESS – sometimes the doublets are matched to a final overall thickness that is tighter than the individual element on large production runs.

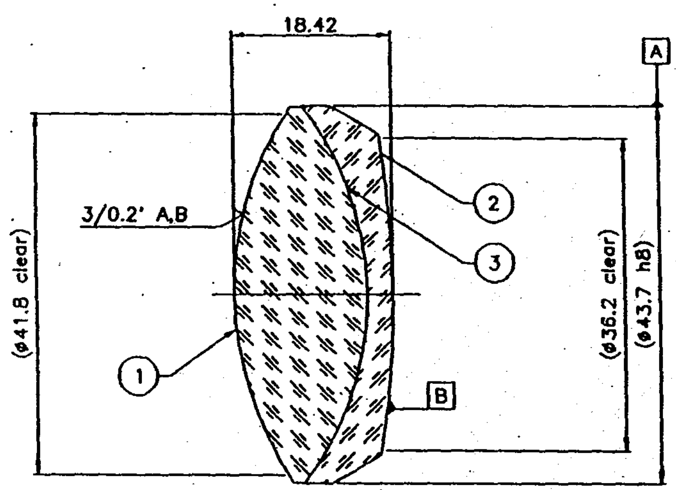


SAMPLE DOUBLET DRAWING

DWG NO	SH.	REV.
702150		A

REVISIONS

REV	DESCRIPTION	DATE	APPROVED
A	PRODUCTION RELEASE	98-06-22	B Ross



NOTES:

1. INTERPRET MECHANICAL DIMENSIONS AND TOLERANCES PER ASME Y14.5M
2. INTERPRET OPTICAL TOLERANCES PER ISO 10110
3. BOND ITEM 2 TO ITEM 1 USING ITEM 3
4. BLACKEN GROUND EDGES USING INK (item 4)

QTY	REQD -001	FSCM NO	PART OR IDENTIFYING NO	NOMENCLATURE OR DESCRIPTION	ITEM NO
	AR		EL70-002	WORNOW INK, M-O-N, BLACK	4
	AR		EL20-006	OPTICAL CEMENT, NORLAND 61	3
	1		702143-001	LENS 9, C583	2
	1		702142-001	LENS 8, C583	1

PARTS LIST

PART DASH NO.	NEXT ASSY	USED ON
-001	901682-001	901557-001
	APPLICATION	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN mm TOLERANCES ARE:
< 30 ±0.1
30 TO 120 ±0.15
>120 ±0.2
ANGLES ±0°30'

MATERIAL 3

SURFACE FINISH 1.6

APPROVALS		DATE
DWN	B ROSS	98-06-22
MDES		
ODES		
PROD		
COAT		
QA		
CMO		

ELCAN OPTICAL TECHNOLOGIES

DOUBLET 8-9

SIZE	FSCM NO	DWG NO	REV
B	36126	702150	A
SCALE 2/1	REF: PAN24	SHEET 1 OF 1	

PROPRIETARY

800183-FEB/98

PART NO. CONSISTS OF DRAWING NO. PLUS DASH NO.

PRISMS

–Prism Drawings follow the same rules and practices as lens element drawings.

The only additional information that is unusual to prisms is PYRAMIDAL ERROR. This is defined as 'a lack of parallelism between the edges formed by the faces of a prism.

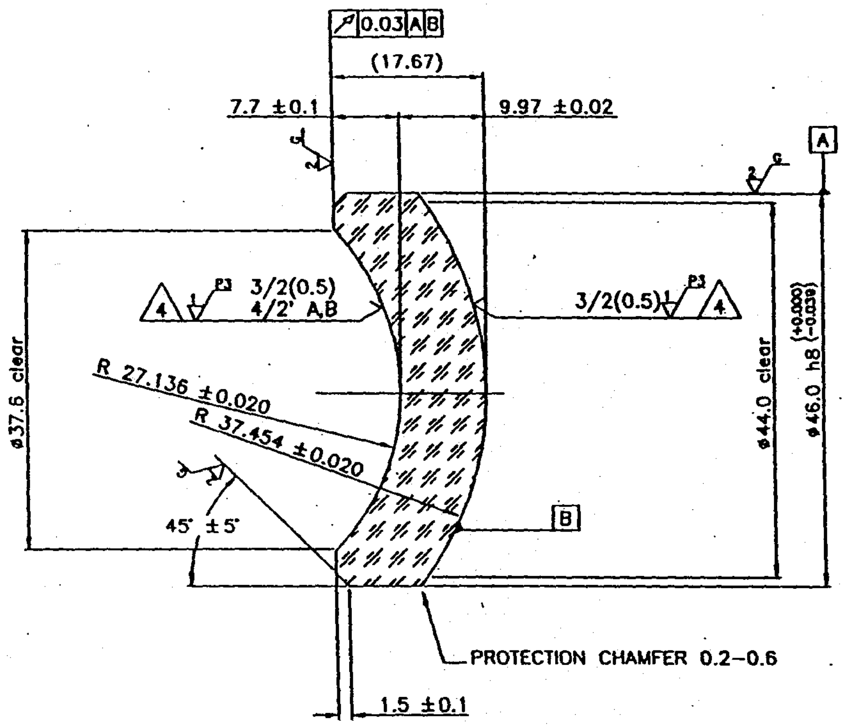
This is usually covered by a note stating that pyramidal error cannot exceed a certain tolerance value.

SAMPLE LENS DRAWING

DWG NO	SH.	REV.
702139		A

REVISIONS

REV	DESCRIPTION	DATE	APPROVED
A	PRODUCTION RELEASE	98-06-19	B Ross



NOTES:

1. INTERPRET MECHANICAL DIMENSIONS AND TOLERANCES PER ASME Y14.5M
2. INTERPRET OPTICAL TOLERANCES PER ISO 10110
3. (△3) MATERIAL: S-FSL5(ohara)
   ALTERNATES: FSL5 (ohara), FK5 (schott), FC5 (hoya), A8770 (corning france)
   Nd= 1.48749 ±0.0001
   Vd= 70.2 ±0.8%
   -MATERIAL ABSORPTION TO BE LESS THAN OR EQUAL TO MOST RECENT MANUFACTURER CATALOG VALUES OVER WAVEBAND 400-700nm.
   -HOMOGENEITY: ±2 x 10E-05
   -BUBBLES: CLASS B3 (PER SCHOTT DEFINITION)
4. (△4) COAT INDICATED SURFACES AS FOLLOWS:
   MULTILAYER ANTIREFLECTION COATING TO MEET ISO COLOUR BALANCE WHEN MEASURED THROUGH FINISHED LENS ASSEMBLY. THE ISO CCI ORIGIN IS SHIFTED FROM (0/0/0) TO (-3/0/0) WHILE THE SIZE OF THE HEXAGON AREA IS MAINTAINED (FOR TOLERANCE FIELD SEE ANNEX B TO ISO 6728-1983A).
   ENVIRONMENTAL TEST ACCORDING TO MIL-C-48497A para 4.5.3.1, 4.5.3.2, AND 4.5.5.1 :
5. SURFACE QUALITY 60-40 PER MIL-PRF-13830
6. BLACKEN GROUND EDGES USING INK (item 1)

QTY REQD -001	FSCM NO	PART OR IDENTIFYING NO	NOMENCLATURE OR DESCRIPTION	ITEM NO
AR		EL70-002	WORNOW INK, M-O-N, BLACK	1

PARTS LIST

PART DASH NO.	NEXT ASSY	USED ON
-001	901679-001	901557-001
	APPLICATION	

PROPRIETARY

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN mm TOLERANCES ARE:
< 30 ±0.1
30 TO 120 ±0.15
>120 ±0.2
ANGLES ±0°30'

MATERIAL △3

SURFACE FINISH 1.6

APPROVALS		DATE
DWN	B ROSS	98-06-19
MDES		
ODES		
PROD		
COAT		
QA		
CMO		

ELCAN OPTICAL TECHNOLOGIES

LENS 5, C583

SIZE	FSCM NO	DWG NO	REV
B	36126	702139	A
SCALE 2/1	REF: PAN24	SHEET 1 OF 1	

800193-FEB/98

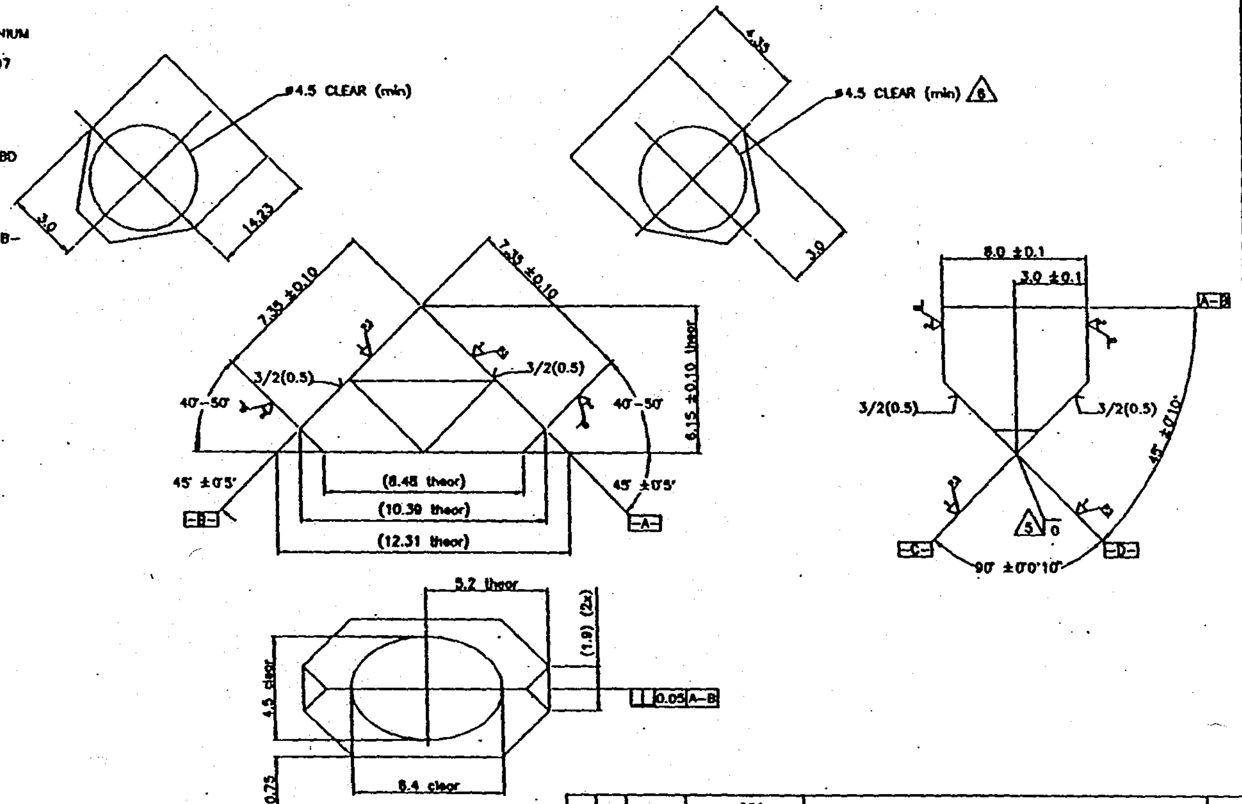
PART NO. CONSISTS OF DRAWING NO. PLUS DASH NO.

SAMPLE PRISM DRAWING

REV	DESCRIPTION	DATE	APPROVED
A	PRODUCTION RELEASE	97-07-17	

NOTES:

1. INTERPRET MECHANICAL DIMENSIONS AND TOLERANCES PER MIL-T-31000 AND MIL-STD-100
2. INTERPRET OPTICAL TOLERANCES PER ISO 10110
3. MATERIAL: GERMANIUM MAKE FROM MONOCRYSTALLINE OPTICAL GRADE N-TYPE (5-30ohm-cm) GERMANIUM
4. SURFACE QUALITY F-F PER MIL-C-48497
5. ROOF CHIPS NOT TO EXCEED 40 DIG OUTSIDE THE CLEAR APERTURE, AND 20 DIG INSIDE THE CLEAR APERTURE PER MIL-O-13830
6. COAT INDICATED SURFACE AS FOLLOWS:TBD
7. PROTECTION CHAMFER EDGES (EXCEPT ROOF PRISM) 0.2-0.4
8. DATUM A-B IS THE THEORETICAL SHARP INTERSECTION OF SURFACE -A- AND -B-



			-001		
QTY	REQD	FSCM NO	PART OR IDENTIFYING NO	NOMENCLATURE OR DESCRIPTION	ITEM NO

PARTS LIST

-001	701869-001	901486-001
PART DASH NO.	NEXT ASSY	USED ON
	APPLICATION	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN mm TOLERANCES ARE: < 30 ±0.1, 30 TO 120 ±0.15, >120 ±0.2, ANGLES ±0°30'

MATERIAL 3

SURFACE FINISH 1.6

	APPROVALS	DATE
DWN	B ROSS	97-07-17
MFG		
DES		
PROD		
COAT		
QA		
CHKD		

HUGHES ELCAN OPTICAL TECHNOLOGIES

ROOF PRISM

SIZE	FSCM NO	DWG NO	REV
C	36126	701857	A
SCALE 8/1	REF. ogile Ibeaba	SHEET 1 OF 1	

PART NO. CONSISTS OF DRAWING NO. PLUS DASH NO.

DWG NO 701857 REV A