TUTORIAL ON SPECIFYING OPTICAL COMPONENTS USING ISO 10110 STANDARDS

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Agenda

- Introduction to Optical Specification Standards
  - (Section 1)
- Sections 2-13 of ISO 10110 Standard Specification
- ISO 10110 Drawings
- Q & A

Introduction

- ISO 10110 standard created to provide universal understanding of drawings and specifications of optics
- 13 sections with detailed description on how to specify optical components
- GD&T mechanical drawings practices apply
- First-angle projection (not third angle)
- Other optical standards:
  - ASME/ANSI Y14.18M-1986
  - MIL-STD-34
  - DIN 3140

ISO 10110 Table of Contents

Part	Title	Indication
1	General	N/A
2	Material imperfections – Stress birefringence	0/
3	Material imperfections – Bubbles and Inclusions	1/
4	Material Imperfections – Inhomogeneity and Striae	2/
5	Surface form tolerances	3/
6	Centering Tolerances	4/
7	Surface Imperfection tolerances	5/
8	Surface Texture	
9	Surface Treatment and coating	
10	Table representing data of a lens element	N/A
11	Non tolerance data	N/A
12	Aspheric surfaces	N/A
13	Laser irradiation damage threshold	6/

Material Imperfections

- Stress Birefringence (sec. 2)
  - Anisotropic index of refraction across an optic
  - Indication: 0/A in nm/cm

$$A = \Delta s/a = K\sigma$$

Δs = optical path difference (nm)
a = sample thickness (cm)
K = stress optic coefficient difference (nm/cm)/(kg/mm^2)
σ = stress (kg/mm^2)

- Bubbles and inclusions (sec. 3)
  - Bubbles: Pockets of trapped gas within the glass
  - Inclusions: Opaque or highly scattering regions within glass
  - Indication: 1/NxA, where N is # of max. sized defects, A is grade # in mm of the max. size defect allowed

- Inhomogeneity and striae (sec. 4)
  - Inhomogeneity: Variation of index of refraction within an optics
  - Striae: localized changes of the index of refraction
  - Indication: 2/A;B, where A, B are the class #s for homogeneity and striae

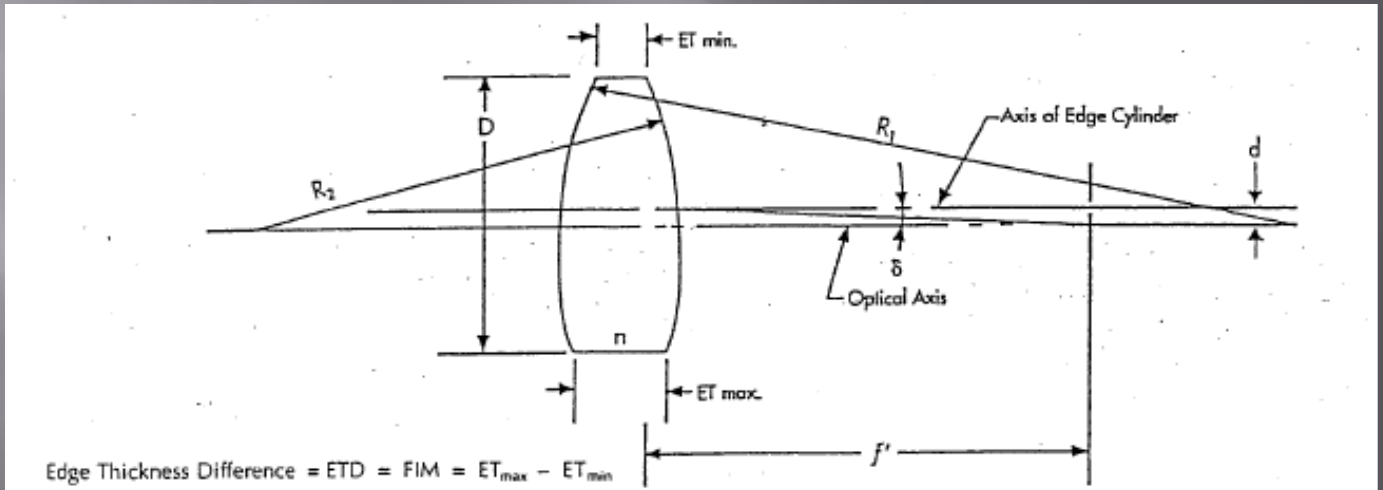
Surface Form Tolerances (sec. 5)

- Indication: 3/A(B/C) RMSs < D (all Ø…)

Tolerance place holder and name		Tolerance definition
A	Saggita tolerance	This is the P-V deviation of the best fit sphere from a sphere with the nominal radius of curvature.
B	Irregularity	The P-V error relative to the best fit spherical surface.
C	Rotationally symmetric irregularity	The P-V of the best fit aspheric surface.
D	RMS_t	RMS departure from a sphere with the nominal radius of curvature.
	RMS_i	RMS departure from the best fit spherical surface.
	RMS_a	RMS departure from the best fit aspheric surface.
(all Ø…)		Size of Aperture over which the surface form tolerances apply.

Centering Tolerances (sec. 6)

- Specification of surface tilt and edge run-out (ERO)
- Indication: 4/σ or 4/σ(L), where σ max. tilt (arc-min or arc-sec), L is max lateral displacement (mm)



Edge Thickness Difference = ETD = FIM = $ET_{max} - ET_{min}$

Surface tilt = $\frac{ETD}{D}$

$\delta = \frac{ETD}{D} \times f' (n-1) \times \frac{1}{0.00029}$ = deviation in minutes

$d = \delta f' = \frac{ETD}{D} \times \frac{1}{1/R1 - 1/R2}$ where f' = focal length

Edge runout = 2d

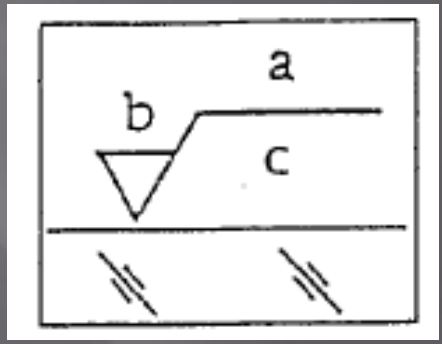
Surface Imperfections (sec. 7)

- Specification of Scratches and digs

- Indication: 5/NxA; LZ x F
  - N = max. # of digs
  - A = max size of digs (mm)
  - Z = max. # of scratches
  - F = width of widest scratch (mm)
  - L = indicates “long scratch”

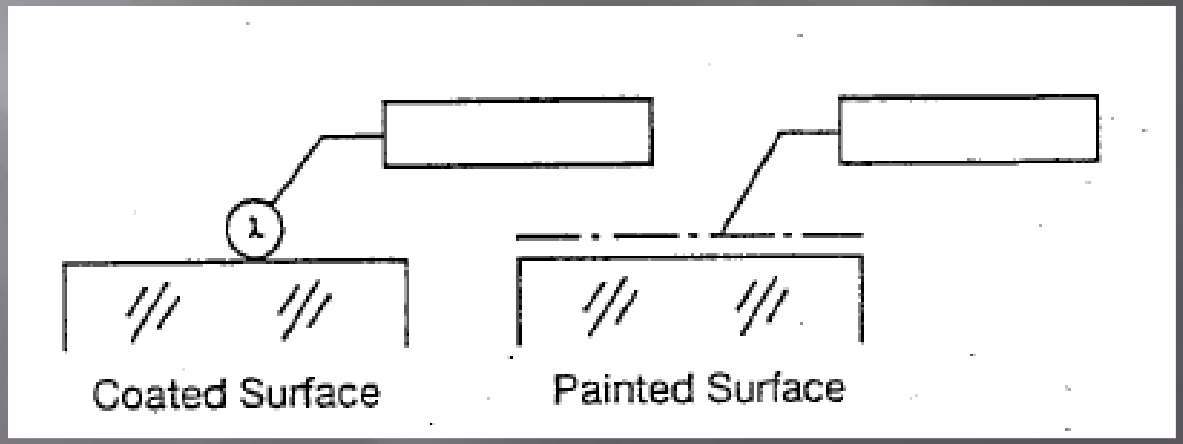
Surface Texture (sec. 8)

- Matte Surfaces – Grinded or chemically etched
  - Intentionally scatter light diffusely into large angles
- Specular Surfaces – produce very little scattered light
- Indication: See image below
  - A = surface type (P for polished, G for ground)
  - B = Indicates RMS or PSD measurement
  - C = Indicates sampling length (mm)



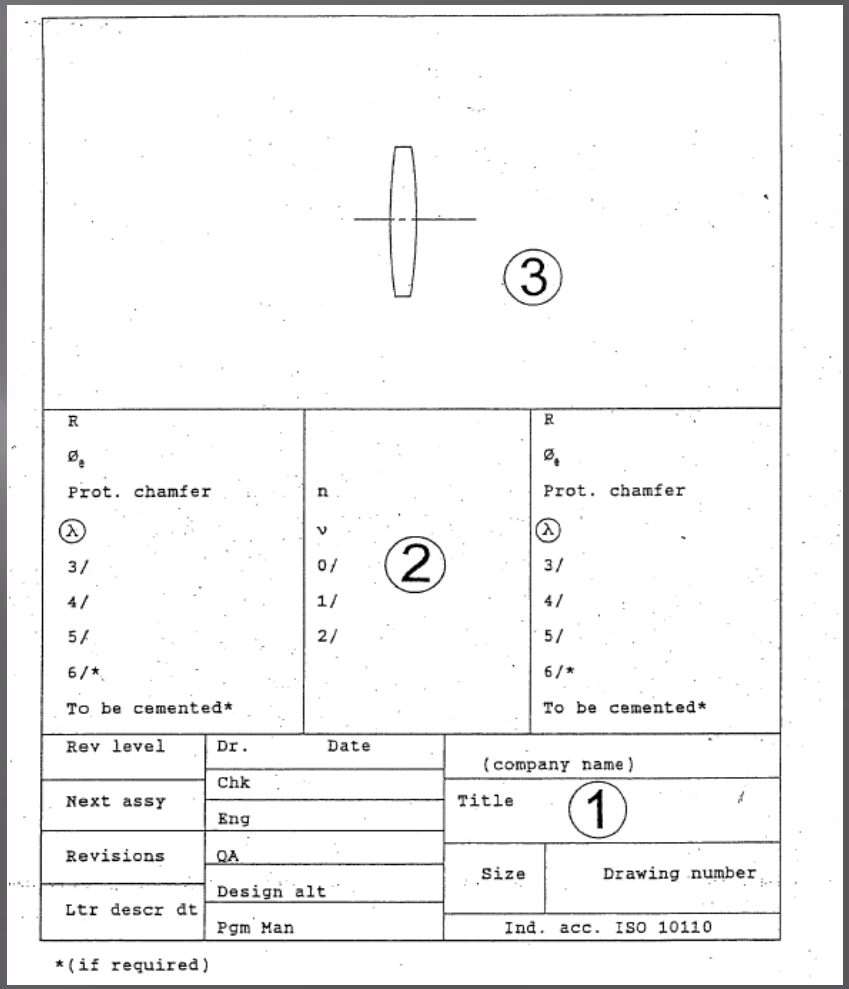
Surface Treatment (sec. 9)

- Specification of surface treatment and coating
  - AR, dichroic, reflective, etc.
- Indication: Lambda in a circle



Tabular Form (sec. 10)

- Element drawing separated into 3 zones
  - Zone 1: Typical drawing title block (name, part #, manufacturer, etc.)
  - Zone 2: Space for tabular lens data (3 fields)
    - Field 1: Left surface specifications
    - Field 2: Material specifications
    - Field 3: Right surface specifications
  - Zone 3: Illustration of part



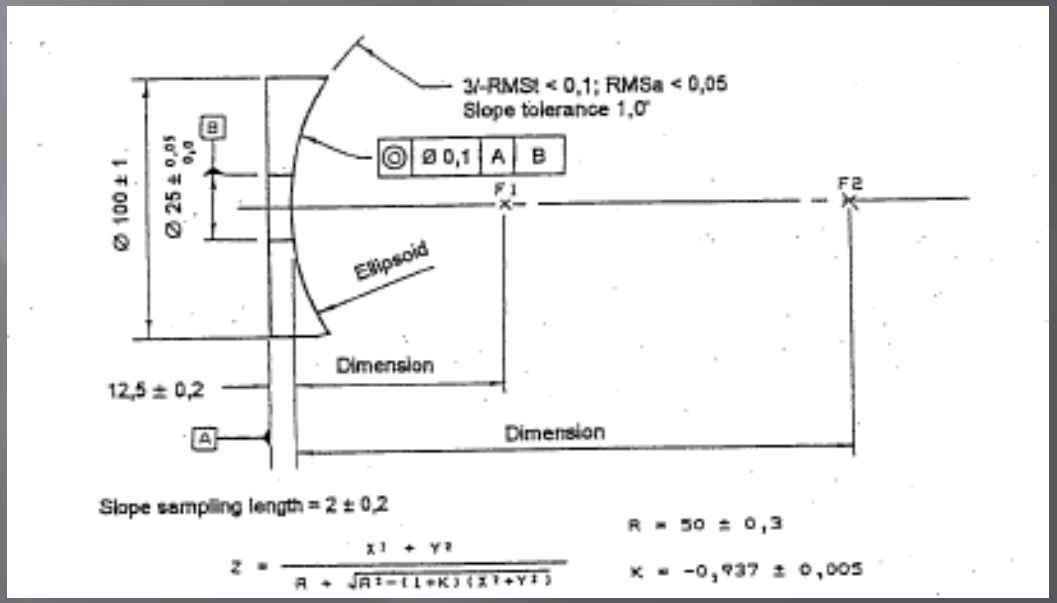
Non-Toleranced Data (sec. 11)

- Standard tolerances to a feature with non-toleranced data

Property	Range of maximum (diagonal) dimension of the part [mm]			
	up to 10	over 10 up to 30	over 30 up to 100	over 100 up to 300
Edge length, diameter [mm]	±0,2	±0,5	±1	±1,5
Thickness [mm]	±0,1	±0,2	±0,4	±0,6
Angle deviation of prisms and plate	±30'	±30'	±30'	±30'
Width of protective chamfer [mm]	0,1 - 0,3	0,2 - 0,5	0,3 - 0,8	0,5 - 1,6
Stress birefringence acc. to ISO/DIS 10110-2 [nm/cm]	0/20	0/20	-	-
Bubbles and inclusions acc. to ISO/DIS 10110-3	1/3x0,16	1/5x0,25	1/5x0,4	1/5x0,63
Inhomogeneity and striae acc. to ISO/DIS 10110-4	2/1;1	2/1;1	-	-
Surface form tolerances acc. to ISO/DIS 10110-5	3/5(1)	3/10(2)	3/10(2) (all Ø 30)	3/10(2) (all Ø 60)
Centring tolerances acc. to ISO/DIS 10110-6	4/30'	4/20'	4/10'	4/10'
Surface imperfection tolerances acc. to ISO/DIS 10110-7	5/3x0,16	5/5x0,25	5/5x0,4	5/5x0,63

Aspheric Surfaces (sec. 12)

- Same rules apply to specifying aspheres
- Exceptions:
  - Term "asphere" must be indicated on drawings along with equation
  - Sag table provided on drawing



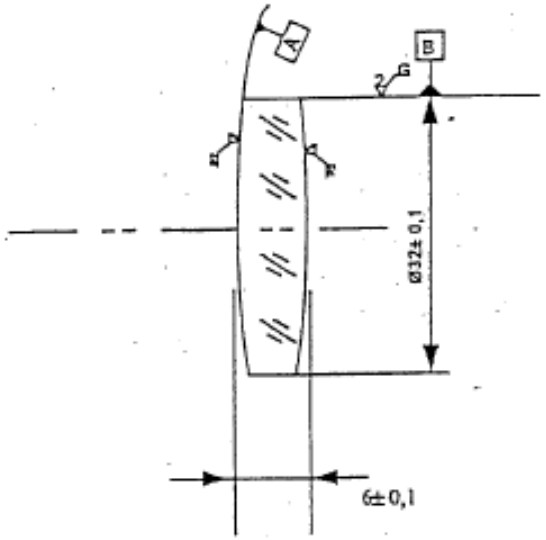
Drawing indications for an ellipsoid

Laser Damage Threshold (sec. 13)

- Defines the energy density which surface damage should not occur when surface is irradiated with a laser (units J/cm^2)

- Indication:
  - Pulsed lasers: $6/H_{th}$; λ; pdg; f_p; n_{TS} x n_P
  - Continuous lasers: $6/E_{th}$; λ; n_{TS}
  - λ = wavelength
  - "pdg" = pulse duration group number from ISO 11254
  - "f_p" = pulse repetition rate in Hz
  - "n_{TS}" = number of test sites on the sample surface
  - "n_P" = number of laser pulses applied to each site

ISO 10110 Drawing Sample



$$Z = \frac{y^2}{R\left(1+\sqrt{1-(1+k)y^2/R^2}\right)} + \sum_{i=3}^{4} B_{2i}\,y^{2i}$$

$R = 52,01 \qquad B_4 = 4,218\,E-9$

$K = -5,63 \qquad B_6 = -1,039\,E-11$

y	Z	Δ Z	slope error tolerance
0	0	0	0,1'
5	0,2379	0,003	0,3'
10	0,9266	0,044	0,5'
15	2,0087	0,201	0,8'

Left Surface	Material Specification	Right Surface
R Aspheric Øe 30,0 Protective chamfer 0,4 ± 0,2 Coating 527,021 3/5(1) 4/- 5/5x0,25; L3x0,1;E0,4 6/-	BK7 Ne 1,5972 ± 0,001 Ve 63,96 ± 0,8% 0/10 1/5x0,16 2/0,1	R 68,224 cx Øe 29,5 Protective chamfer 0,4 ± 0,2 3/5(1) 4/1,5' 5/5x0,16; L2x0,5 6/-

Rev Level	Dr Date	OPTICS R US INCORPORATED
Next Assy	Chk	Title
Revisions	Eng	Objective Lens no.1
Ltr Descr dt	QA	Size A Drawing number 70862B

Ind Acc ISO 10110

Questions?

Thank You

Backup

Classes of Homogeneity and Striae

Homogeneity Class Numbers

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

Striae Class Numbers

Striae class	Density of striae causing an optical path difference of at least 30 nm in %
1	≤ 10
2	≤ 5
3	≤ 2
4	≤ 1

5	Extremely free of striae The restriction to striae exceeding 30 nm does not apply Further information to be specified in a note

References

- Kimmel, R. K., Parks, R. E., *ISO 10110 Optics and Optical Instruments – Preparation of drawings for optical elements and systems: A User's Guide*, Second Edition, OSA, 1995.

- Yoder, P., *Opto-Mechanical Systems Design*, Third Edition, CRC Press, 2006.