Builds upon surface form tolerance specification where notation changes from 3/ to 13/

Tolerances for optical materials are determined by three main groups

1. X/ = subassembly tolerance

Additional methods are possible to describe an optical

Coefficients and equation needed to describe the surface must be listed and referred

(2017).

Both aspheric and rotationally non-

the

Copy

B = PV irregularity in fringes by default, but can be specified in nm or

N

Part 9: Surface

use

A = PV power in fringes by default, but can be specified in nm or

z

(2016).

1

ISO 10110

A pulse is considered long when the thermal transit distance, (2 D

Phase

(2017).

In both cases,

only

Edge corners

Striae can either be specified by a grade number or the more common shadowgraph class

Default

purposes,

When a dash is present following 6/, or the 6/ is not included, the laser damage threshold is not defined and will not be tes

Forbes, G. W. & Brophy, C. P., "Interferometer

error when tested at 632.8 nm

= surface roughness in microns

L = maximum lateral displacement

A = axial runout at the clear aperture

E = edge chips

When a dash or nothing is listed in place of one of the tolerances, that type of tolerance will not be applied

Surface Imperfections and Evaluation

• imperfections can be described by two methods

- Visibility imperfections (ISO material standard): 5/ D, 6/ D, 7/ D

- Each group represents different types of imperfections

- B/D = surface scratch and dig designation

- Accumulation and concentration rules apply.


- Each group with a different prefix classification types of imperfections

- No = Pre-Tol. general surface imperfections

- C = imperfections on across a coating

- L = long wavelength outside of general surface imperfections

- E = edge chips

- Each designation is listed in two methods

- X = number of imperfections within a grade class

- A = grade class to characteristics imperfections

- Accumulation and concentration rules apply

Surface Form Tolerances and Evaluation

• Surface texture: Polish code above the texture symbol is either P (polished), G (ground) or P1-4 (polish grades) which indicate a default specification of surface texture

- Tolerances are specified separated by a /,

- Spatial wavelengths are given in mm

- Rj indicates rms surface roughness in microns

- Rq indicates rms surface slope in micrometers

- PSD indicates the maximum value of the power spectrum over the specified spatial wavelength band, given as a power coefficient and an exponent in mm

- When upper and lower limits are provided they are indicated with an U or an L

- When the lay of the measurement is provided it is indicated as R (radial), C (circular), L (vertical) or (horizontal)

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Laser Damage Threshold

- Written as 6/ A(C/B/D)

- X can either be one of three conditions depending on the type of laser irradiation

- Pulsed laser irradiation:

- Tm = Thermal energy density in units of J/cm

- Em = Threshold power density in units of W/cm

- Limited by the OIR limit of the material

- Fm = Threshold linear power density in units of W/cm

- Echo = Effective edge power density

- When a dash is present following 6/ or the 6/ is not included, the laser damage threshold is not defined and will not be tested

Material Imperfections

- Tolerances for optical materials are determined by three main groups

- Stress birefringence: 5/ A

- A = maximum allowable optical path difference (OPD) in units of nm/cm

- Value specified needs to be measurable using a single-pass metrology method, typically found to be an interferometer

- Bubbles and inclusions: 1/ X A

- A = grade of the bubble determined by the square root of the projected area

- N = number of bubbles collected by a method of accumulation

- Hygroscopic and plastic:

- A = hygroscopic grade based on tolerance limits of material

- B = stress quality based on either the density or the wavefront deviation for a given material path

- Stress can either be specified by a grade number or the more common shadowgraph class

Wavelength Deformation from an Element of Assembly

- Bulbs; applies surface form tolerance specifications where rotation changes from 31/ to 13/ A

- Written as 13/ ABC) RMS D = E

- Value specified needs to be measurable using a single-pass metrology method, typically found to be an interferometer

- Specification would be shown on the drawing or in a total system specification section of the table

- Assembly deformation example:

- RMS = 0.014, A = 0.022 mm

- Exemplar states that the measured total rms wavefront error needs to be less than 0.4 waves different from the result expected or wavefront error when tested at 532 nm

- When a dash or nothing is listed in place of one of the tolerances, that type of tolerance will not be applied

Aspheric and Rotationally Non-Valient Surfaces

- Both aspheric and rotationally non-variant surfaces are tolerance based on their surface form.

- A table with (az) (az) and (dz) (dz) should be included

- Aspheric surfaces are surfaces that are rotationally non-variant about the optical axis

- Surface shape is described through a multi-term expansion:

- Conic section and a power series

- Zernike polynomials

- Aspheric and rotationally non-variant surfaces are surfaces that are rotationally non-variant about the optical axis

- Surface shape is described through a multi-term expansion:

- Conic section and a power series

- Zernike polynomials

- Multiple types of equations commonly referred to as Zernike surfaces

- Coefficients and equation needed to describe the surface must be listed and referred in the surface radius designation

General Notation

- Drawings can be prepared for an optical element or subassembly

- Default conditions unless stated otherwise:

- Temperature = 20°C

- Dimensional Units = mm

- Each tolerance property is applied for multiple cases:

- X = element tolerance

- U = subassembly tolerance

- DD = raw material tolerance

- Fundamental dimensions for a rotationally invariant optical element

- Radius = dimensional value preceded by an R and the curvature orientation (cr or cc)

- Thickness = dimensional value including tolerances unless otherwise specified

- Diameter = dimensional value including tolerances

- Effective diameter = (s) to aperture where optical tolerances apply

- Edge corners

- Bevel; functional corner specified with a dimension and angle

- Angular + B = functional corner specified as the maximum or minimum allowed angle

- Unless stated within each tolerance where a wavelength value is necessary, the title block must include default wavelength values

- The following optical material information needs to be listed, either

- Manufacturer and optical material

- Multiple manufacturers may be listed for a given element

- International glass code

- The index and Abbe information

- Material specifications at n using, n using, n using, and n and

- However, the glass is specified, the tolerance on the index and dispersion must be indicated

Surface Treatment and Optical Coatings

- Functional coatings are indicated by a circle in a circle

- "As defined in ISO 10742 descriptions and applications of an optical coating must precede the specifications for spectral characteristics (e.g. Antireflecting[AR] or Filtering[FI])

- Coatings specifications can primarily be broken down into three designs:

- (S) or (T) = transmission for a waveband

- (x) or (R) = reflectance for a waveband

- Additional methods are possible to describe an optical coating waveband

- Angle of incidence (AOI)

- Antireflective (AR)

- Polarization orientation

- Phase shift

- Surface treatments

- Indicate the optic by a thick chain line adjacent to the treated region

- Specifications are written in a box with a leader line to the treated region

- Surface treatment application

- Mitigate damage to the optic (e.g. handling, environmental effects)

- Provide functional uses outside main use of the optic (e.g. stay light control)