

**Smithsonian Astrophysical Observatory
Specification Bin-010**

Binospec Calcium Fluoride Lenses

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Calcium Fluoride Blank Specifications

Introduction

The CaF_2 lens blanks for Binospec shall be grown as a crystal by the Stockbarger technique. Although the delivered lens blanks may be cut from a twinned crystal, the lens blanks cannot be formed by pressing, melting or forging together smaller crystals; such blanks are commonly termed polycrystalline material, and are not acceptable.

SAO will require a CaF_2 sample to verify that the refractive indices of the Optron material are consistent with the values that we are using from the literature. The required sample is a cube, 25 to 35 mm on a side, and will be returned to Optron after the measurements are made. The indices will be measured by Ohara in Japan at SAO's expense, and Optron may elect to deliver the sample directly to Ohara. The sample should be taken from a boule that will yield a Binospec lens blank if at all possible. If this is not possible, the sample should come from a large boule produced by the same process used to produce the Binospec lenses.

1. Index of Refraction Homogeneity

Goal: 3 parts per million PV or better

Worst Case: 6 parts per million PV or better

Test Technique: Polished plates are oiled to the lens blank and the assembly is measured with an 18 inch ZYGO Mark IV Interferometer.

Measurement Accuracy: +/-1.5 parts per million

2. Transmission

Specification: Less than 1% internal transmission loss through 50 cm path length between 390 and 1000nm.

Test Technique: Two samples from the production run, each at least 10 cm thick will be measured with a Hitachi U-3410 Spectrophotometer operating as a double monochromator. The surface reflection losses will be removed by measuring a thin sample with the same instrument.

Measurement Accuracy: +/-0.3%

3. Stress Birefringence

Goal: Less than 12nm/cm

Worst Case: Less than 17nm/cm

Test Technique: A Uniopto Auto-birefringence Meter type ABR-10A-40A will be used to scan each blank over its surface at a 10mm pitch.

Measurement Accuracy: +/-1 nm/cm

4. Bubbles and Inclusions

Specification: Bubbles and inclusions of different sizes will be given severity points. The bubbles and inclusions in each blank must be graded at 10 points or less. Bubbles and inclusions less than 0.1 mm in size will not be counted, and no bubbles or inclusions larger than 0.3 mm will be acceptable.

Points: 0.10 to 0.15 mm: 1 point
0.16 to 0.20 mm: 2 points
0.21 to 0.30 mm: 3 points

Test Technique: Visual

5. Twinning

Crystal twinning is acceptable.

Lens Polishing Specifications

All lens surfaces are to be polished in a craftsman-like manner with no visible chips or damage in the clear aperture. Any chip outside the clear diameter shall be etched or ground to remove cracks or other subsurface damage. Following this etching or grinding, no defects larger than 2 mm in diameter or 1 mm deep are allowed outside the clear aperture. No cracks or other types of visible damage shall be present anywhere on the polished lens.

For the radius of curvature and departure from sphericity measurements, the lenses must be tested in a carefully temperature controlled environment with a temperature of 24 ± 2.0 °C. The lens temperature (accurate to 0.5 °C) at the time of the radius of curvature measurements shall be recorded and transmitted to SAO.

1. Test Plates

SAO will supply Pyrex test plates for each surface. A total of 12 different test plates will be required. The test plate diameters will be 150 mm for the lenses less than 260 mm in diameter, 175 mm for the lens with a finished diameter of 303 mm, and 200 mm for the larger lenses. The accuracy of the polished surface figure will be assessed with these test plates. The surface figure of the test plates will be accurate to 1/10 wavelength of light over their surfaces. (Here and throughout this specification the reference wavelength is 6328 Angstroms.)

2. Radius of Curvature Tolerance

The radius of curvature of each surface will match that of the appropriate test plate to 2 wavelengths of light over the test plate diameter. This is equivalent to 4 fringes when testing the lens with a test plate. The final radius of curvature (and fringe count concave or convex) shall be reported to an accuracy of 0.5 fringe or better. The optical design will be retweaked to account for manufacturing tolerances; this is why SAO requires accurate as-built radii of curvature.

Due to the large thermal expansion of CaF_2 , precise thermal control and isothermal lenses are critical for these measurements. For the more steeply curved surfaces, changing the temperature by 4 °C will change the fit to the test plate by the 2 wavelength tolerance.

3. Departure from Sphericity

The polished surface shall not depart from a purely spherical shape by more than one sixth wavelength (one third fringe) of light over the test plate diameter when the test plate is anywhere within the clear aperture. Smooth surfaces are desirable, and high spatial frequency errors should be minimized.

Due to the large thermal expansion of CaF_2 , the lenses must be allowed sufficient time to equilibrate with their surroundings and to become isothermal before these measurements are undertaken. Temperature gradients in the lenses can invalidate the measurements.

4. Edge Thickness Uniformity

The edge thickness of the lenses will be held uniform to 15 microns, referred to the outer diameter of the lenses. The lens drawings give further information about the mechanical tolerances.

5. Center Thickness Tolerance

± 0.2 mm, report as-built thicknesses to an accuracy of ± 0.020 mm or better. The optical design will be retweaked to account for manufacturing tolerances; this is why SAO requires accurate as-built thickness.

6. Scratch/Dig

60/40 per mil spec

7. Surface Finish

Better than 30 Angstroms RMS assessed with a WYCO interferometer or equivalent.

8. Other specifications

Additional specifications for edge bevels, ground surface finish and alignment of the edge girdle with the optical axis will be found on the final lens drawings.