First Ten Ångstroms

Contact Angle Standard Calibration: One Standard Per Block Models

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Scope

The standard consists of precision sapphire or glass lens embedded in an aluminum support block. The portion of the lens that protrudes above the support creates an image that is the same as a small drop of water and the software then analyzes this for contact angle.

This description refers to models that have one lens per block. This is contrasted with models which have three lens embedded in one block.

The uncertainty in the manufacturing process is how much the lens protrudes. This is what is measured in the final certification. This measurement is converted to the equivalent contact angle by simple geometry. The manufacturing uncertainty arises from the fact the lens are secured with epoxy and its thickness can not be controlled perfectly during its cure.

Geometry

If H represents the protruding height and D the diameter of the lens, then the contact angle θ is defined by geometry as

$$\theta = 2 \arctan (2H / D)$$

This is the angle formed by a tangent to the lens at the point the lens surface meets the supporting block.

The uncertainties in the calculation are the uncertainty in the measured height and the lens diameter. The "15.9°" and "39.6°" lens diameters are specified to 6mm ±50μm. The "90°" lens diameter is 6mm ±2.5μm.

Physical Measurements

The protruding height is determined by measuring the thickness of the support block adjacent to the lens and also the total thickness of the lens plus the block. The height H is the difference in the two. The protruding height certification document contains a sketch showing the relationship between the "item" number and the location on the block. Normally the block's base thickness

is measured on each side of the lens. These measurements will be the smaller ones of the set. The larger measurement will be that of the base plus the lens. The measurements may be made in either customary English or metric. The units do not matter as they will divide out.

Certification Measurement Uncertainty

The total uncertainty in the calculated contact angle is determined by calculating the worst cases (e.g., maximum H and minimum D, or minimum H and maximum D) of the ratio and then passing them through the arctan function to obtain an angle. The difference in the worst cases shows the range for the particular nominal angle.

As an example, assume the certification measurements are made to an accuracy of $\pm.0001" = \pm2.54\mu m$. If another accuracy is used, the uncertainty will scale linearly with it. The following table shows results of the min/max calculations.

Case	Nominal H (mm)	Nominal D (mm)	2H/D Min/Max	Angle (°)	Error (°)
90°	3	6	2(3.0025)/5.9975	90.071	+.071
90°	3	6	2(2.9975)/6.0025	89.928	-.072
39.6°	1.08	6	2(1.0825)/5.950	39.989	+.389
39.6°	1.08	6	2(1.0775)/6.050	39.212	-.388
15.94°	0.42	6	2(0.4225)/5.950	16.166	+.225
15.94°	0.42	6	2(0.4175)/6.050	15.716	-.224

Note this error is not the total error in the standard, but rather is the uncertainty to which the standard can be specified within the certification process.

Example Data

The table below shows representative data from the protruding height measurement. The original measurements are made in inches and then the metric equivalent computed. Locations 1A and 1B are the thickness of the aluminum support at different locations. These numbers show the degree of flatness in the support. We use the average of the thickness numbers to represent the support in the subsequent protruding height calculation. Location 2 is, for example, the protruding height of the 90° lens.

Item Location	Test Instrument
1A	.2544" = 6.462 mm
1B	.2545" = 6.464 mm
2	.3716" = 9.439 mm

From this data we can then compute the contact angles for each standard. You will notice that the calculated angle does not match the nominal angle exactly. The average support thickness is 6.463 mm from the measured data in the table.

Item	Total Height	Protruding Height	Contact Angle
2, "90.0"	9.439 mm	2.976 mm	89.54°

You should use the actual contact angle number shown in the right column rather than the nominal angle that is the label. For example, use 89.54° in this example rather than 90.0°.

When we consider the measurement uncertainty, the angle from this example is

89.54° ± .07°

Quality Control

Each standard is measured on FTA video equipment to ensure that it indeed will be measured within its specification. The video equipment is not as accurate as the mechanical measurements (as one would expect). However the video test ensures there is nothing drastically wrong, and that the standard can be used on video equipment. The acceptance requirement is that the video measured angle be within ±1° of the mechanical angle. It is typically within ±0.7°.

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