

# NATIONAL PHYSICAL LABORATORY

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## Certificate of Calibration

ANNULUS STANDARD  
MEC-001

*This certificate provides traceability of measurement to recognised national standards, and to the units of measurement realised at the National Physical Laboratory or other recognised national standards laboratories. This certificate may not be reproduced other than in full, unless permission for the publication of an approved extract has been obtained in writing from the Managing Director. It does not of itself impute to the subject of calibration any attributes beyond those shown by the data contained herein.*

FOR  
Arden Photonics Ltd  
IBIC Holt Court South  
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Birmingham  
B7 4EJ

DESCRIPTION  
An Annulus Standard, shown in Figure 1, consisting a circle formed on a glass square plate approximately 10 mm x 10 mm x 2mm. The approximate mean diameter of the circle is 0.125 mm. Rectangular alignment marks denote the horizontal and vertical centreline of circle.

The coefficient of linear expansion used for this calibration is  $8.5 \times 10^{-6} / ^\circ\text{C}$ .

DATE OF  
CALIBRATION 22 September 2008

IDENTIFICATION Serial Number MEC-001.  
The box containing the Annulus Standard is marked MPX Calibration.

Reference: LR0401/E08090433/ML77/80

Page 1 of 3

Date of issue: 8 October 2008 Signed:  (Authorised Signatory)

Checked by:  Name: BRUCE DUNCAN for Managing Director

# NATIONAL PHYSICAL LABORATORY

Continuation Sheet

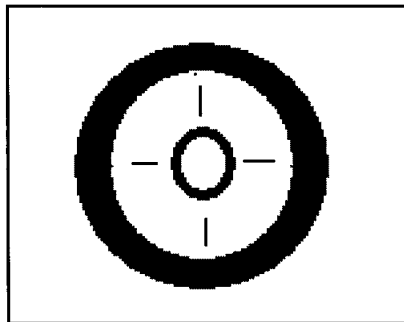


Figure 1: Annulus Standard.

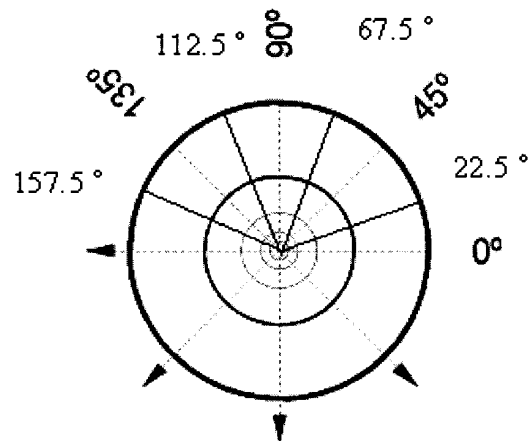


Figure 2: Circle Pattern.

## MEASUREMENTS

The diameter at selected intervals on the smallest circle pattern shown in Figure 1 have been measured using a microscope fitted with a travelling stage. The stage is driven by a motor and positioned finely with a piezoelectric transducer. A Zeeman frequency-split laser interferometer monitors the position of the stage.

The laser has been calibrated with respect to an iodine-stabilised reference laser and the wavelength has been corrected for variations in atmospheric conditions. An image analysis system is used to ensure that the scale lines are positioned centrally in the field of view of the microscope. The measurements were taken in a room with temperature maintained to  $20^\circ \pm 1^\circ\text{C}$ .

The standard was supported on a flat surface with the main inscriptions uppermost and viewed using reflected light. To ensure that diameters were measured, the smallest circle was centred in the field of view of the image analyser. The centre of each line was determined from the average of the line intensity profile within this area. The standard was measured in eight different orientations, nominally  $0^\circ$ ,  $22.5^\circ$ ,  $45^\circ$ ,  $67.5^\circ$ ,  $90^\circ$ ,  $112.5^\circ$ ,  $135^\circ$ , and  $157^\circ$ , as shown in Figure 2.

Reference: LR0401/E08090433/ML77/80

Page 2 of 3

Checked by: *L. P. N. M. G. K. A. V. D.*  
*Am*

# NATIONAL PHYSICAL LABORATORY

Continuation Sheet

## RESULTS

All values are quoted in mm. Each value is the average of three measurements and is the length of the interval at 20°C.

Intervals	Measured Length
0°	0.124 9
22.5°	0.124 8
45°	0.124 7
67.5°	0.124 7
90 °	0.124 8
112.5°	0.125 0
135°	0.124 7
157°	0.124 8

## UNCERTAINTIES

The expanded uncertainty in the interval measurements is  $\pm 0.000 1$  mm.

The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor  $k=2$ , providing a level of confidence of approximately 95%.

NOTE: The results and uncertainties refer to on the day values and make no allowance for subsequent drift.

Reference: LR0401/E08090433/ML77/80

Page 3 of 3

Checked by: Lp Nimishadav,  
SD