# Calibration of Low-Modulus Photostress® Coatings by the Imposed-Curvature Method

## Introduction

Calibration of low-modulus PhotoStress coatings is not practical using the Model PSC-1 Calibrator. These coatings are more conveniently calibrated by the imposed-curvature method described here (Figure 1). The estimated accuracy of this procedure is ±5%.

*Figure 1*

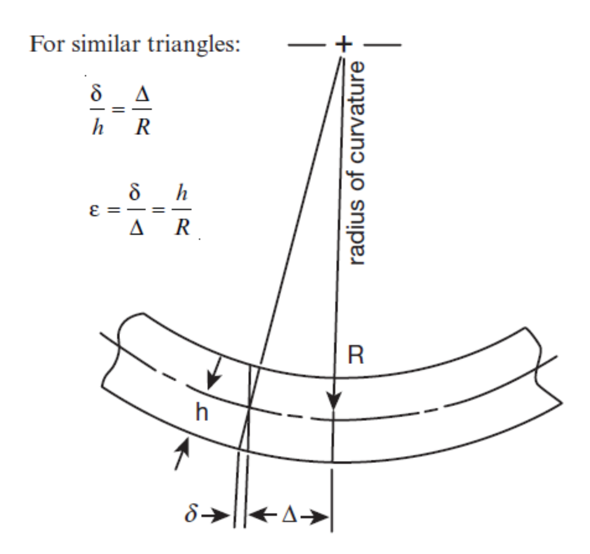
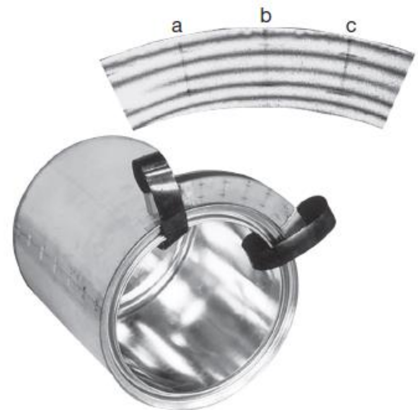



*Figure 2*


## Calibration Test Setup

Item 1 of Figure 2 shows a 0.75 D x 0.50 T x 4.00 L in calibration beam made from Type PSM-4 material, with Type PL-3 low-modulus coating bonded to both sides. Coating thickness measurements (t) were made at points a, b, and c prior to bonding. Spring clamps (Item 2), were then used to produce a known radius of curvature (R) on the beam by clamping it against a clean, rigid, cylindrical surface (Item 3). A soft resilient strip (Item 4) was placed between the beam and the can. The PhotoStress pattern that results in the center portion of the beam, and from which fringe orders are measured, is shown in Figure 3. Slight radial pressure (stress) which may create uncertainties in the strain field along this interface exists between the beam and the can. For this reason, it is prudent to confine fringe measurements to the outside convex surface of the calibration beam.

## Calculations

The PhotoStress relationship is

$(\varepsilon_1 - \varepsilon_2) = \frac{\lambda}{2k} \times \frac{N}{t}$; then $k = \frac{\lambda}{2(\varepsilon_1 - \varepsilon_2)} \times \frac{N}{t}$

where: $\lambda = 22.7(10)^{-6}$ and $\varepsilon_1$, $\varepsilon_2$ are the maximum and minimum principal strains. The outside, convex surface of the beam is in uniaxial tension; hence, $\varepsilon_2 = -\nu\varepsilon_1$ where $\nu$ = Poisson's ratio. Then,

$$k = \frac{\lambda}{2\varepsilon_1\ (1+\nu)} \times \frac{N}{t}$$

In this example, the calibration beam is PSM-4 model material and $\nu = 0.50$. The radius of curvature (R) to the center of the beam is R = 3.625 in. From Figure 1, the principal strain $\varepsilon_1 = h/R = 0.375/3.625 = 0.103$ in/in. Then,

$$k = \frac{\lambda}{2\varepsilon_1\ (1+\nu)} \times \frac{N}{t} = \frac{22.7*10^{-6}}{2(0.103)(1.5)} \times \frac{N}{t} = 73.5*10^{-6} \times \frac{N}{t}$$

Measurements and the calculated values of k, for Type PL-3 coating, are tabulated below:

| Point | Thickness t | Fringes N | N/t | k = $73.5*10^{-6}*$ N/t |
|---|---|---|---|---|
| a | 0.096 in | 2.58 | 26.9 | 0.0020 |
| b | 0.091 in | 2.50 | 27.5 | 0.0020 |
| c | 0.087 in | 2.47 | 28.4 | 0.0021 |