

For the most accurate measurement of the coefficient of linear thermal expansion (CTE), it is necessary to calibrate the expansion response of the thermomechanical analyzer (TMA) using reference materials. Aluminum and borosilicate glass are two common reference materials. Furthermore, standard reference texts (e.g. the American Institute of Physics Handbook [1] and ASTM E831 [2]) provide tables of expansion ( $\epsilon$ , in  $\mu\text{m}/\text{m}$  or ppm) and CTE ( $\alpha$ , in  $\mu\text{m}/\text{m}^\circ\text{C}$  or ppm/ $^\circ\text{C}$ ) versus temperature (T) data for these materials. In addition, ASTM recommends the following method for use of these tables for calibration of thermomechanical analyzers.

1. Interpolate from the table the expansion value for the initial temperature ( $T_i$ ) of your calibration range. This value is  $\epsilon_{\text{lit},i}$ . Also calculate  $\epsilon_{\text{lit},f}$  for the final temperature ( $T_f$ ).
2. Calculate the reference CTE over your temperature range as:

$$\alpha_{\text{ref}} = \frac{\epsilon_{\text{lit},f} - \epsilon_{\text{lit},i}}{T_f - T_i} \quad (1)$$

3. Run an experiment on the reference material in the TMA with a force of 0.001 N to 0.05 N (0.1 to 5 g). The temperature range should be from 20  $^\circ\text{C}$  below the temperature range of interest to 20  $^\circ\text{C}$  above. The TMA cell constant should be reset to 1.0.
4. Analyze your data for CTE ( $\alpha_{\text{exp}}$ ) using the “point-to-point” method.
5. The new cell constant is defined as  $K = \alpha_{\text{ref}}/\alpha_{\text{exp}}$ .

Note: This procedure provides calibration only over the temperature range selected. Furthermore, the expansion curves of most materials are not straight lines, and the values of expansion coefficient may differ significantly with small changes in the temperature range chosen. In general, ASTM suggests that precision (reproducibility) for CTE measurements is on the order of 5%.

## REFERENCES

1. American Institute of Polymer Handbook, D.E. Gray Ed., McGraw Hill, NY, 1982, pp 4-119 to 4-140.
2. The American Society for Testing and Materials, Vol. 8.03, Philadelphia, PA.

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This applications note was submitted by Jon Foreman of the Applications Laboratory (US).

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