GMP 9

Good Measurement Practice for Equations for Metallic Tapes

Table 1. Symbols used in this practice.

Symbol	Description
L	Horizontal straight-line distance
L_S	Calibrated length of the tape interval on a flat surface at T_S and P_S
L_n	Designated nominal length of the tape interval
P	Applied tension
P_S	Standard tension applied to the tape interval for L_S
AE	Average cross-sectional area times Young's Modulus of Elasticity
T	Temperature
T_S	Standard temperature of the tape interval for L_S, 20 °C (68 °F)
α	Coefficient of thermal expansion of the tape ribbon
W	Average weight per unit length of the tape ribbon
N	Number of equidistant catenary suspensions
P_O	Tension of accuracy (Tension of accuracy is defined as that tension which must be applied to the tape interval to produce its designated nominal length at the observed temperature of the tape.)
P_C	Tension of accuracy while the tape is supported in catenary suspensions

The horizontal straight-line distance, L, of a tape interval can be computed by the following equation for an applied tension, P, and temperature, T, when the tape is supported for N, number of equidistant catenary suspensions. When both a standard tape and a tape to be calibrated are placed in a catenary suspension condition, the horizontal straight line distance for the compared intervals for each tape must be calculated. Intervals can be compared only at the supported points along the tape length.

$$L = L_S + \frac{L_n(P - P_S)}{AE} + L_n(T - T_S)\alpha - \frac{L_n(W * L_n / N * P)^2}{24} \qquad (1)$$

For simplicity, it is recommended to entirely support the tape on a horizontal flat surface for calibration. When the tape is supported entirely on a horizontal flat surface, N = ∞, and the general equation is reduced to:

$$L = L_S + \frac{L_n(P - P_S)}{AE} + L_n(T - T_S)\alpha \qquad (2)$$

The distance, L, of the tape interval can be set to the designated nominal length, L_n, for determining the tension of accuracy, P_O, while the tape is supported on a flat surface, by writing equation (2) as follows:

$$L_n = L_S + \frac{L_n(P_O - P_S)}{AE} + L_n(T - T_S)\alpha \qquad (3)$$

from which the following equations are developed:

$$P_O = P_S + \frac{AE(L_n - L_S)}{L_n} - AE(T - T_S)\alpha \qquad (4)$$

or

$$P_S = P_O - \frac{AE(L_n - L_S)}{L_n} + AE(T - T_S)\alpha \qquad (5)$$

Substituting equation (5) for P_S in the general equation (1), we have

$$L = L_n + \frac{L_n(P - P_O)}{AE} - \frac{L_n(W * L_n / N * P_C)^2}{24} \qquad (6)$$

The distance, L, of the tape interval again can be set to the designated nominal length, L_n, for determining the tension of accuracy, P_C, while the tape is supported in catenary suspensions, by writing this equation as follows

$$L_n = L_n + \frac{L_n(P_C - P_O)}{AE} - \frac{L_n(W * L_n / N * P_C)^2}{24} \qquad (7)$$

from which:

$$P_C{}^2(P_C - P_O) = \frac{AE(W * L_n / N)^2}{24} \qquad (8)$$

or

$$P_C{}^2\left[P_C - P_S - \frac{AE(L_n - L_S)}{L_n} + AE(T - T_S)\alpha\right] = \frac{AE(W * L_n / N)^2}{24} \qquad (9)$$

The value of P_C can be solved by first determining the right side of the equal signs in equations (8) or (9), then substituting various values for P_C until the left side approaches the right side within the desired limits. If the value is greater than the right side, reduce the value of P_C.