National Institute of Standards & Technology

Certificate

Standard Reference Material 739

Fused-Silica Thermal Expansion

Thermal Expansion as a Function of Temperature

T	Expansion $\Delta L/L_{293}$	Expansivity α	T	Expansion $\Delta L/L_{293}$	Expansivity α
80 K	-1×10^{-6}	-0.70×10^{-6}/K	320 K	$13_{.5} \times 10^{-6}$	$+0.53 \times 10^{-6}$/K
90	$-7_{.5}$	-0.61	340	$24_{.5}$	0.56
100	-13	-0.53	360	36	0.58
110	-18	-0.46	380	$47_{.5}$	0.60
120	$-22_{.5}$	-0.38	400	$59_{.5}$	0.61
130	-26	-0.31	420	72	0.62
140	$-28_{.5}$	-0.24	440	85	0.63
150	$-30_{.5}$	-0.17	460	97	0.63
160	-32	-0.10	480	110	0.63
170	$-32_{.5}$	-0.04	500	122	0.63
180	$-32_{.5}$	+0.02	520	135	0.62
190	-32	0.08	560	159	0.61
200	-31	0.13	600	183	0.59
210	$-29_{.5}$	0.19	640	206	0.56
220	$-27_{.5}$	0.23	680	228	0.54
230	-25	0.28	720	249	0.51
240	-22	0.32	760	269	0.49
250	$-18_{.5}$	0.36	800	288	0.47
260	-14	0.39	840	307	0.44
273	-9	0.43	880	324	0.42
280	-6	0.45	920	340	0.40
293	0	0.48	960	356	0.38
298	$+2_{.5}$	0.49	1000	371	0.37

This SRM is available as a rod 6.4 mm (1/4 in) in diameter; L1 is 51 mm (2 in) long, L2 is 102 mm (4 in) long, and L3 is 152 mm (6 in) long. The rods that make up this SRM were obtained as a single drawing from an ingot of fused silica, at least 99.8 wt. percent pure. These rods have already been annealed by soaking at 1373 K for 7 hours and cooling to 1173 K at 12 K per hour.

The above values of expansion and expansivity were calculated from a least squares fit to expansivity measurements made on five speciments. Linear interpolation can be used between tabulated values without introducing a significant error. The expansion of this material may be altered, however, if the material is heated to temperatures above 1020 K. A description of the experimental method, fitting procedure, and estimate of uncertainties is given on the back of this certificate.

Gaithersburg, MD 20899
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(Revision of certificate dated 5-12-71)

William P. Reed, Chief
Standard Reference Materials Program

(over)

Technical measurements and evaluation of data leading to certification were performed by R.K. Kirby and T.A. Hahn.

The technical and support aspects involved in the original preparation, certification, and issuance of this Standard Reference Mate were coordinated through the Standard Reference Materials Program by R.E. Michaelis. Revision of this certificate and issua of the Standard Reference Material was coordinated through the Standard Reference Materials Program by J.C. Colbert.

PROCEDURE

The apparatus used for the expansion measurements was a Fizeau interferometer with a 1-cm specimen length. Above ro temperature, the measurements were made with the interferometer in a controlled atmosphere furnace using a Pt vs Pt-10 % thermocouple. Below room temperature, a cryostat operating with liquid nitrogen was used with a platinum resistance thermome The green spectral line of a mercury light source was used to produce the interference fringes. Fringe motion was measured v a filar-micrometer eyepiece. Each test specimen was made by fastening three 1-cm pieces of the SRM rod in holes drilled thro a thin fused-silica ring. A small amount of a thin slurry of fused-silica cement was used to fasten the rods in the ring. With uncertainties of temperature and fringe measurements, the expansivity was determined with an uncertainty of $\pm$ 0.03 X 10^{-6}/K.

Values of expansivity were calculated between equilibrium temperatures, and corrections [1] were made for the finite temperat differences. The tests on the 5 specimens indicated that no gross differences existed, and that the expansion is reversible if temperature does not exceed 1050 K. All of the data were pooled and the following third-order polynomial was obtained by method of least squares using an Omnitab routine:

$$\begin{aligned}\alpha \times 10^{6}\ \mathrm{K} = {} & -1.417 + 9.581 \times 10^{-3}\, T - 5.991 \times 10^{-6}\, T^{2} \\ & -1.5642 \times 10^{-8}\, T^{3} - 6.666 \times 10^{-6}\, (T-300)_{+}^{2} \\ & +2.2128 \times 10^{-8}\, (T-300)_{+}^{2}(T+600) \\ & +1.013 \times 10^{-5}\, (T-700)_{+}^{2} \\ & -5.37 \times 10^{-9}\, (T-700)_{+}^{2}(T+1400)\end{aligned}$$

where the notation $(\ )_{+}$ means that the term is zero when the quantity in the parentheses is negative. The standard deviation of t fit is 0.026 with 169 data points. This equation and its integral were used to calculate the tabulated values of expansivity a expansion. A standard deviation of 6 X 10^{-5} was calculated for the expansion values.

[1] Hahn, Thomas A., Thermal Expansion of Copper from 20 to 800 K - Standard Reference Material 736, J. Appl. Phys. 41, 5096 (1970).