National Institute of Standards & Technology

Certificate

Standard Reference Material 731 (L1, L2, and L3)

Borosilicate Glass - Thermal Expansion

This Standard Reference Material (SRM) is intended for use in calibrating dilatometers used in the measurement of thermal expansion. It is available as individual square rods each with 6.4 mm (1/4 in) sides; 731L1 is 51 mm (2 in) long, 731L2 is 102 mm (4 in) long, and 731L3 is 152 mm (6 in) long. This borosilicate glass is from the same lot as SRM 717, Borosilicate Glass Viscosity Standard, with a nominal composition of 70% SiO_2, 17% B_2O_3, 8% K_2O, 3% Al_2O_3, 1% Na_2O, and 1% Li_2O. The index of refraction after fine annealing is $N_D = 1.4874$. These rods were annealed at 789 K, cooled to 743 K at a rate of 2 K/h, and then cooled to 523 K at a rate of 5 K/h.

Fitting Procedure: Values of expansivity were calculated between equilibrium temperatures and corrections were made using the following equation:

$$\alpha = \frac{1}{L_{293}} \left(\frac{dL}{dT}\right)$$

where "α" is the expansivity.[1]

Tests on the specimens used for certification indicated no appreciable differences. All of the data were pooled and the following third-order spline polynomials were obtained by the method of least squares using Omnitab routine:

at $100 \leq T \leq 293$,

$$\alpha \times 10^6 = -0.8194 + 4.7611 \times 10^{-2}T - 1.4753 \times 10^{-4}T^2 + 1.7153 \times 10^{-7}T^3$$

at $293 \leq T \leq 640$,

$$\alpha \times 10^6 = 0.8651 + 2.3569 \times 10^{-2}T - 4.2277 \times 10^{-5}T^2 + 2.5408 \times 10^{-8}T^3$$

The standard deviation of this fit is 0.06 with 88 data points. These equations and their integrals were used to calculate the values listed in the table. A comparison of the experimental expansion data with values predicted from the equations gives a standard deviation of 8×10^{-6}. All of the data for both the expansion and expansivity were within two standard deviations of the values predicted by the equations.

The overall coordination and evaluation of data leading to certification of this Standard Reference Material was performed by T.A. Hahn, formerly of NIST.

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

Gaithersburg, MD 20899
June 30, 1993
(Revision of certificate dated 7-31-72)

Thomas E. Gills, Acting Chief
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(over)

Experimental Method: The apparatus used for the expansion measurements was a Fizeau interferometer with a 1-cm specimen length. Above room temperature, the measurements were made with the interferometer in a controlled atmosphere furnace using a Pt vs Pt-10% Rh thermocouple. Below room temperature, a cryostat operating with liquid nitrogen was used with a platinum resistance thermometer. The green spectral line of a mercury light source was used to produce the interference fringes. Fringe motion was measured with a filar-micrometer eyepiece. Each test specimen was made by fastening three 1-cm rods of the SRM to a Kovar ring to form a three-point contact for the interferometer plates.

Table 1
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	-819×10^{-6}	---	293 K	0×10^{-6}	4.78×10^{-6}/K
90	- 797	---	300	34	4.82
100	- 771	2.64×10^{-6}/K	320	131	4.91
110	- 744	2.86	340	230	4.99
120	- 714	3.07	360	330	5.06
130	- 683	3.25	380	432	5.11
140	- 649	3.43	400	535	5.15
150	- 614	3.58	420	638	5.19
160	- 578	3.72	440	742	5.21
170	- 540	3.85	460	847	5.23
180	- 501	3.97	480	952	5.25
190	- 460	4.08	500	1057	5.26
200	- 419	4.17	520	1162	5.26
210	- 377	4.26	540	1267	5.27
220	- 334	4.34	560	1372	5.27
230	- 290	4.41	580	1478	5.27
240	- 246	4.48	600	1583	5.27
250	- 201	4.54	620	1689	5.28
260	- 155	4.60	640	1794	5.29
270	- 109	4.66	660	1900	
280	- 62	4.71	680	2007	

Note: The above values of expansion and expansivity were calculated from equations based on a least squares analysis of the expansivity data from six specimens taken from various positions of the stock. With the uncertainties in temperature and fringe measurements, the expansivity was determined with an uncertainty of $\pm$ 0.03 x 10^{-6}/K.

REFERENCE

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