U. S. Department of Commerce
Malcolm Baldrige
Secretary
National Bureau of Standards
Ernest Ambler, Director

National Bureau of Standards

REPORT OF INVESTIGATION

RESEARCH MATERIALS 8424, 8425, and 8426

Graphite

Thermal Conductivity (λ) and Electrical Resistivity (ρ) as a Function of Temperature (IPTS-68 and NBS P2-20) from 5 to 2500 K

J. G. Hust and A. B. Lankford

These Research Materials (RM's) are for use in testing methods for measuring thermal conductivity and electrical resistivity. RM 8424 is available in rod form 0.64 cm in diameter and 5.0 cm long. RM 8425 is 1.27 cm in diameter and 5.0 cm long. RM 8426 is 2.54 cm in diameter and 5.0 cm long.

Measurements

These RM's are the result of a large scale investigation to select and establish the best graphite available for several thermophysical properties. This project extended over a period of 19 years: beginning with the AFML-AGARD (Air Force Materials Laboratory, Dayton, Ohio-Advisory Group for Aerospace Research and Development, NATO) program in 1965 [2] and ending with the CODATA (Committee on Data for Science and Technology) program in 1983 [1]. Hundreds of characterization data were obtained for electrical resistivity, thermal conductivity, density, thermal expansion, specific heat, and thermal diffusivity. A complete description of this international effort is given in reference [1]. These characterization data showed that this graphite is inhomogeneous from specimen-to-specimen by over 20% in the thermal conductivity and electrical resistivity. Because graphite has so many other useful characteristics, a strong effort was made to correlate these variations with relatively simple measurements. At room temperature correlation between conductivity, electrical resistivity, and density was found that reduced the effect of this material variability to below the measurement uncertainty. This correlation was applied to data for other temperatures. The results are in agreement to within the estimated uncertainty of the experimental data. The values given here (corrected for thermal expansion) are for specimens with a room temperature electrical resistivity of 14.5 $\mu\Omega\cdot$m and a density of 1730 kg/m^3. Data for other specimens are given in reference [1].

The uncertainty of the values of thermal conductivity are estimated to be 2% below 300 K. The uncertainties increase at higher temperatures, approaching 10% at 2500 K. The uncertainties of the electrical resistivity values are 2% below 300 K and increasing to 3% at higher temperature.

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Gaithersburg, MD 20899

Stanley D. Rasberry, Chief
Office of Standard Reference Materials

(over)

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T(K)	λ(W·m^{-1}·K^{-1})	$\rho(\mu\Omega\cdot$m)	T(K)	λ(W·m^{-1}·K^{-1})	$\rho(\mu\Omega\cdot$m)
5	0.0354	28.78	240	86.4	15.97
6	.0537	28.73	260	88.8	15.44
7	.0783	28.67	280	90.4	14.96
8	.1099	28.62	300	91.3	14.52
9	.1494	28.55	400	90.2	12.83
10	.1971	28.48	500	84.6	11.74
15	.573	28.11	600	78.0	11.03
20	1.201	27.71	700	71.7	10.58
25	2.095	27.28	800	65.9	10.30
30	3.255	26.85	900	60.9	10.15
35	4.675	26.43	1000	56.5	10.10
40	6.33	26.00	1200	49.48	10.19
45	8.23	25.59	1400	44.28	10.43
50	10.32	25.19	1600	40.46	10.76
60	15.03	24.41	1800	37.67	11.14
70	20.25	23.68	2000	35.66	11.55
80	25.81	22.98	2200	34.25	11.96
90	31.51	22.33	2400	33.29	12.38
100	37.21	21.72	2500	32.96	12.59
120	48.16	20.60			
140	57.9	19.60			
160	66.4	18.71			
180	73.3	17.92			
200	78.9	17.20			
220	83.2	16.55			

[1] Hust, J.G., A Fine-Grained, Isotropic Graphite for Use as NBS Thermophysical Property RM's from 5 to 2500 K, Nat. Bur. Stand. Special Publication 260-89 (1984).

[2] Fitzer, E., Thermophysical Properties of Solid Materials Advisory Report 38 (1972); Report 606 (1973), AGARD, NATO, France.