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Production Filename: 13420 (In Product Library)

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Dimensions: 8.5 inch wide, 11 inch tall

Material: Paper, 92 Bright White or better, 75g/m² or heavier

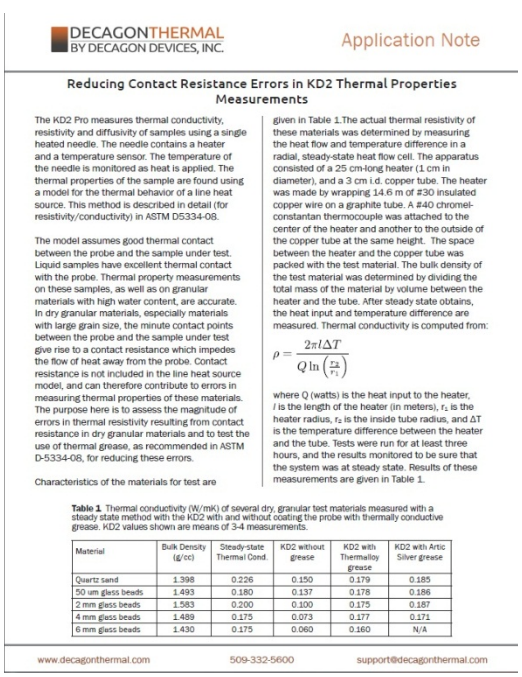
Colors: Color Print on White

Printer: HP Color LaserJet 8550-PS

Finish: None

Adhesive: None

Special Notes: Illustrations are Ref Only ** Not to Scale ** (Shown page 1 of 2)



DECAGONTHERMAL
BY DECAGON DEVICES, INC.

Application Note

Reducing Contact Resistance Errors in KD2 Thermal Properties Measurements

The KD2 Pro measures thermal conductivity, resistivity and diffusivity of samples using a single heated needle. The needle contains a heater and a temperature sensor. The temperature of the needle is monitored as heat is applied. The thermal properties of the sample are found using a model for the thermal behavior of a line heat source. This method is described in detail (for resistivity/conductivity) in ASTM D5334-08.

The model assumes good thermal contact between the probe and the sample under test. Liquid samples have excellent thermal contact with the probe. Thermal property measurements on these samples, as well as on granular materials with high water content, are accurate. In dry granular materials, especially materials with large grain size, the minute contact points between the probe and the sample under test give rise to a contact resistance which impedes the flow of heat away from the probe. Contact resistance is not included in the line heat source model, and can therefore contribute to errors in measuring thermal properties of these materials. The purpose here is to assess the magnitude of errors in thermal resistivity resulting from contact resistance in dry granular materials and to test the use of thermal grease, as recommended in ASTM D-5334-08, for reducing these errors.

Characteristics of the materials for test are given in Table 1.The actual thermal resistivity of these materials was determined by measuring the heat flow and temperature difference in a radial, steady-state heat flow cell. The apparatus consisted of a 25 cm-long heater (1 cm in diameter), and a 3 cm i.d. copper tube. The heater was made by wrapping 14.6 m of #30 insulated copper wire on a graphite tube. A #40 chromel-constantan thermocouple was attached to the center of the heater and another to the outside of the copper tube at the same height. The space between the heater and the copper tube was packed with the test material. The bulk density of the test material was determined by dividing the total mass of the material by volume between the heater and the tube. After steady state obtains, the heat input and temperature difference are measured. Thermal conductivity is computed from:

$$\rho = \frac{2\pi l \Delta T}{Q \ln\left(\frac{r_2}{r_1}\right)}$$

where Q (watts) is the heat input to the heater, l is the length of the heater (in meters), r_1 is the heater radius, r_2 is the inside tube radius, and ΔT is the temperature difference between the heater and the tube. Tests were run for at least three hours, and the results monitored to be sure that the system was at steady state. Results of these measurements are given in Table 1.

Table 1 Thermal conductivity (W/mK) of several dry, granular test materials measured with a steady state method with the KD2 with and without coating the probe with thermally conductive grease. KD2 values shown are means of 3-4 measurements.

Material	Bulk Density (g/cc)	Steady-state Thermal Cond.	KD2 without grease	KD2 with Thermalloy grease	KD2 with Artic Silver grease
Quartz sand	1.398	0.226	0.150	0.179	0.185
50 um glass beads	1.493	0.180	0.137	0.178	0.186
2 mm glass beads	1.583	0.200	0.100	0.175	0.187
4 mm glass beads	1.489	0.175	0.073	0.177	0.171
6 mm glass beads	1.430	0.175	0.060	0.160	N/A