Document Title:

Description, AN, THERM, TR.com How to Reduce Contact Resistance Errors in Thermal Properties Measurements

Part # and Rev.

13944-01

Release Date:

Rev.	Description	Revision By	Date

Production Filename: 13944 (In Product Library)

Path to Working Files: DecaDoc\Application Notes\Master

Dimensions: 8.5 inch wide, 11 inch tall

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

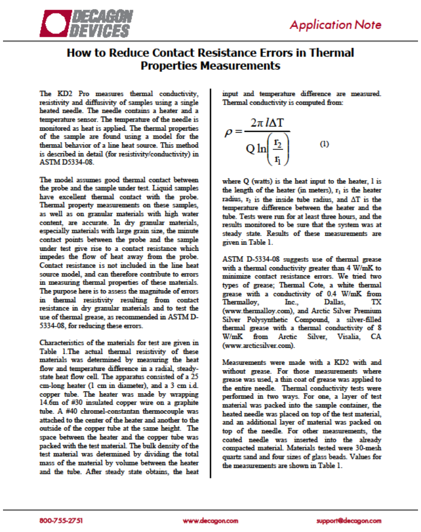
Colors: Color Print on White

Printer: HP Color LaserJet 8550-PS

Finish: None

Adhesive: None

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



DECAGON DEVICES

Application Note

How to Reduce Contact Resistance Errors in 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 14.6m 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:

$$\rho = \frac{2\pi l \Delta T}{Q \ln\left(\frac{r_2}{r_1}\right)} \qquad (1)$$

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.

ASTM D-5334-08 suggests use of thermal grease with a thermal conductivity greater than 4 W/mK to minimize contact resistance errors. We tried two types of grease; Thermal Cote, a white thermal grease with a conductivity of 0.4 W/mK from Thermalloy, Inc., Dallas, TX (www.thermalloy.com), and Arctic Silver Premium Silver Polysynthetic Compound, a silver-filled thermal grease with a thermal conductivity of 8 W/mK from Arctic Silver, Visalia, CA (www.arcticsilver.com).

Measurements were made with a KD2 with and without grease. For those measurements where grease was used, a thin coat of grease was applied to the entire needle. Thermal conductivity tests were performed in two ways. For one, a layer of test material was packed into the sample container, the heated needle was placed on top of the test material, and an additional layer of material was packed on top of the needle. For other measurements, the coated needle was inserted into the already compacted material. Materials tested were 30-mesh quartz sand and four sizes of glass beads. Values for the measurements are shown in Table 1.

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