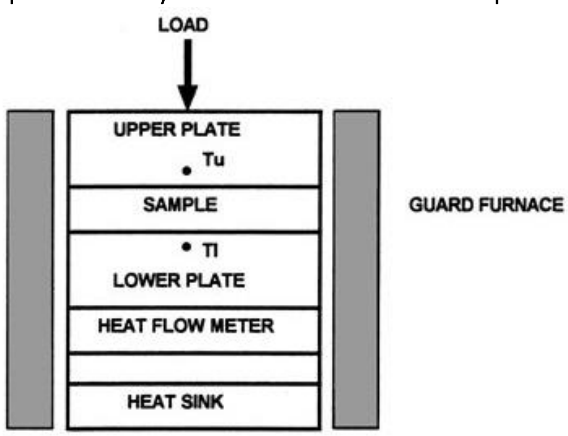
ASTM E1530 Guarded Heat Flow Meter Method

The TA Instruments DTC-25 and DTC-300 Thermal Conductvitity Meters measure thermal conductivity according to the ASTM E1530 guarded heat flow meter method. In this equipment, a small sample of the material to be tested is held under a compressive load between two polished metal surfaces, each controlled at a different temperature. The lower surface is part of a calibrated heat flux transducer. As heat flows from the upper surface through the sample to the lower surface, an axial temperature gradient is established in the stack. By measuring the temperature difference across the sample along with the output from the heat flux transducer, thermal conductivity of the sample can be determined when the thickness is known. In the DTC-300, a guard furnace surrounds the test stack to reduce the effect of heat transfer across the edges of the sample which would cause an error in the measurement. The DTC-25 tests at room temperature only and therefore does not require a guard furnace.



Test Section Schematic

At thermal equilibrium, the Fourier heat flow equation applied to the test stack becomes

$$R_s = F \frac{T_u - T_i}{Q} - R_{int} \quad (1)$$

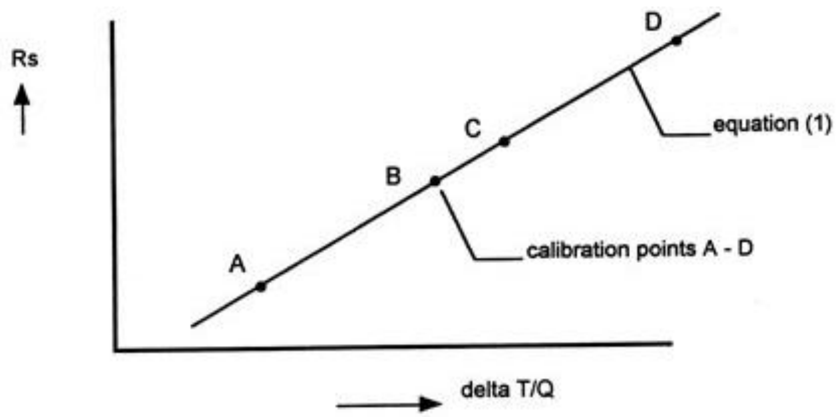
where
R_s = thermal resistance of the sample
F = heat flow transducer calibration factor
T_u = upper plate surface temperature
T_l = lower plate surface temperature
Q = heat flow transducer output
R_{int} = interface thermal resistance

The sample thermal conductivity (λ) is calculated from

$$\lambda = \frac{d}{R_S} \quad (2)$$

where d = sample thickness

In Equation (1), both F and R_{int} are obtained during equipment calibration. Equation (1) shows that there is a linear relationship between R_s and DT/Q. On a graph it can be plotted as a straight line with the slope F and y-axis intersection at $-R_{int}$. By testing several samples of known thermal conductivity, and thus known R_s, corresponding values for DT/Q can be obtained and plotted on the graph. A best fit straight line through the data points becomes Equation (1) and can then be used for subsequent testing of unknown samples.



Guarded Heat Flow Meter Data Analysis

Although R_{int} is accounted for in the data analysis, it is important for obtaining high test accuracy that R_{int} be made as small as possible. This is achieved by using highly polished metal surfaces in contact with the sample, by clamping the sample with a reproducible force, and, if practical, by applying heat transfer compound to the contact surfaces. The axial clamping force is produced in the DTC instruments with a pneumatic cylinder. A pressure regulator ensures reproducible air pressure to the cylinder.

Equation (1) is slightly temperature dependent. Therefore, the DTC-300 must be calibrated at several temperatures resulting in a series of linear equations. Because the coefficients of Equation (1) do not vary much over the temperature range of the instrument, linear interpolation is permitted when testing at sample temperatures in between calibration points. To facilitate the data analysis, TA Instruments provides software for a PC. The user enters data from the digital display of the instrument and thermal conductivity is then automatically computed.

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