



## Testing of Thin Film Thermal Conductivity with the DTC-25 and DTC-300

Very thin materials like plastic film, paper products, and elastomeric insulating pads often have a thermal resistance that falls below the minimum value recommended for accurate testing with the TA Instruments DTC-25 and DTC-300 guarded heat flow meter thermal conductivity instruments. Accurate results can, however, be obtained when thin samples are tested by stacking several layers together, and the resulting thermal resistance values are analyzed as described below.

When testing a stack of thin samples, the overall thermal resistance is obtained from the measured data:

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

where

$R_s$	=	thermal resistance of the stack of samples
$F$	=	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

In equation (1), both  $F$  and  $R_{int}$  are obtained during equipment calibration.  $R_{int}$  is the interface resistance between the sample and the adjacent surface plates.  $R_s$  includes the thermal contact resistance between individual layers if more than one sample is tested. For this method to produce thermal conductivity of the sample material accurately, the contact resistance must therefore be minimized by compressing the sample stack. Thin samples of rigid materials should not be tested by the stacking methods as the interface resistances may exceed the thermal resistance of the sample material itself.

If a stack of maximum five layers produces a thermal resistance greater than  $0.001 \text{ m}^2\text{K/W}$ , thermal conductivity may be calculated from:

$$k = \frac{n \cdot d}{R_s} \quad (2)$$

where

$n$	=	number of film layers
$d$	=	individual film thickness
$R_s$	=	overall thermal resistance of the stack

If up to five layers tested together produces a thermal resistance below  $0.001 \text{ m}^2\text{K/W}$ , better results can be obtained by sandwiching several different layers of sample material between two flat plates, e.g. 10 mm stainless steel, before they are tested in the DTC-25 or DTC-300. The presence of the stainless steel plates raises the measured thermal resistance above the suggested lower limit, thereby ensuring a more accurate measurement. To account for the resistance of the stainless steel plates, this

measurement must be carried out several times, each time with a different number of layers between the plates. A graph of the measured thermal resistance as a function of the number of sample layers tested shows that the data points follow a straight line. Thermal conductivity of the sample material is the reciprocal of the slope of this line. Usually, up to five different layers of thin film material are tested by this method. The number of samples in each layer, ranging from one to ten, depends on the thickness and thermal conductivity of the material.

Software provided with the DTC-25 and DTC-300 includes the data analysis for thin film testing.

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