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03	Update to reflect new firmware, removed KD2	DC, BW	6/8/10

Production Filename: 13422-03 Using the KD2 Pro To Measure Thermal Properties Of Fluids

Path to Working Files: decadoc\Application Notes\Published - To print on Plain paper\Thermal

Dimensions: 8.5 inch wide, 11 inch tall

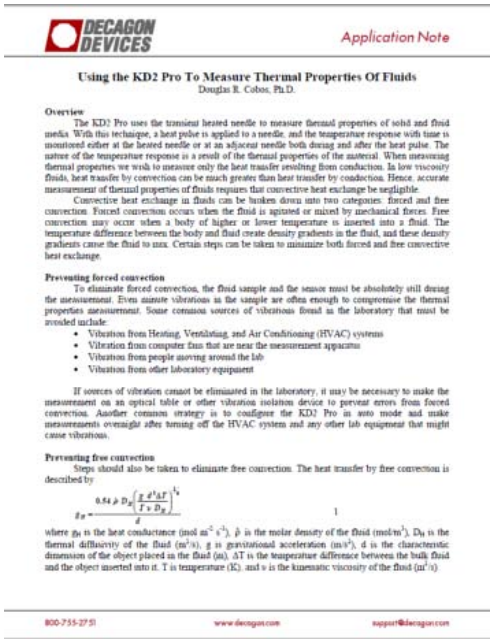
Material: Paper, 92 Bright White or better, 75g/m² or heavier

Colors: Color Print on White

Printer: HP Color LaserJet 5550-PS

Finish: None

Adhesive: None
Special Notes: Illustrations are Ref Only ** Not to Scale **



DECAGON DEVICES Application Note

Using the KD2 Pro To Measure Thermal Properties Of Fluids

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Overview

The KD2 Pro uses the transient heated needle to measure thermal properties of solid and fluid media. With this technique, a heat pulse is applied to a needle, and the temperature response with time is monitored either at the heated needle or at an adjacent needle both during and after the heat pulse. The nature of the temperature response is a result of the thermal properties of the material. When measuring thermal properties we wish to measure only the heat transfer resulting from conduction. In low viscosity fluids, heat transfer by convection can be much greater than heat transfer by conduction. Hence, accurate measurement of thermal properties of fluids requires that convective heat exchange be negligible.

Convective heat exchange in fluids can be broken down into two categories: forced and free convection. Forced convection occurs when the fluid is agitated or mixed by mechanical forces. Free convection may occur when a body of higher or lower temperature is inserted into a fluid. The temperature difference between the body and fluid create density gradients in the fluid, and these density gradients cause the fluid to mix. Certain steps can be taken to minimize both forced and free convective heat exchange.

Preventing forced convection

To eliminate forced convection, the fluid sample and the sensor must be absolutely still during the measurement. Even minute vibrations in the sample are often enough to compromise the thermal properties measurement. Some common sources of vibrations found in the laboratory that must be avoided include:

- Vibration from Heating, Ventilating, and Air Conditioning (HVAC) systems
- Vibration from computer fans that are near the measurement apparatus
- Vibration from people moving around the lab
- Vibration from other laboratory equipment

If sources of vibration cannot be eliminated in the laboratory, it may be necessary to make the measurement on an optical table or other vibration isolation device to prevent errors from forced convection. Another common strategy is to configure the KD2 Pro in auto mode and make measurements overnight after turning off the HVAC system and any other lab equipment that might cause vibrations.

Preventing free convection

Steps should also be taken to eliminate free convection. The heat transfer by free convection is described by

$$g_H = \frac{0.54\,\hat{\rho}\,D_H\left(\frac{g\,d^3\Delta T}{T\times D_H}\right)^{1/4}}{d} \qquad 1$$

where g_H is the heat conductance (mol m^{-2} s^{-1}), $\hat{\rho}$ is the molar density of the fluid (mol/m^3), D_H is the thermal diffusivity of the fluid (m^2/s), g is gravitational acceleration (m/s^2), d is the characteristic dimension of the object placed in the fluid (m), ΔT is the temperature difference between the bulk fluid and the object inserted into it, T is temperature (K), and ν is the kinematic viscosity of the fluid (m^2/s).

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