

# APPLICATION NOTE

## Measuring in a Gradient

An Example of Thermal "Smearing" Produced by Thermocouple Sensors

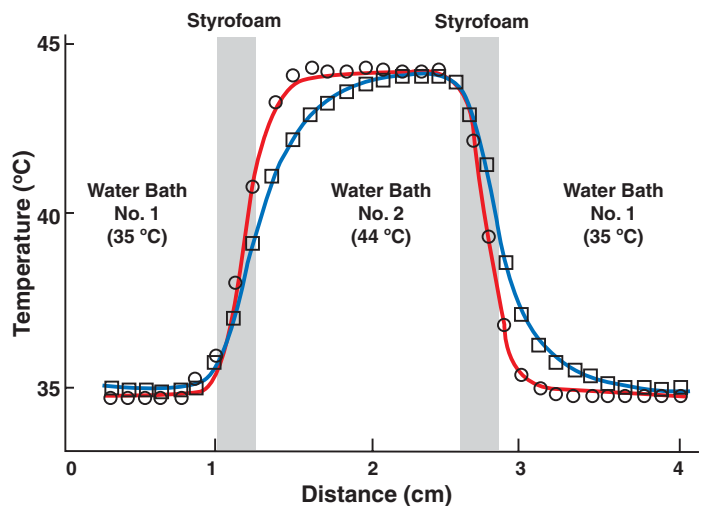
### The Problem:

Metallic leads and needles frequently used for implanting biomedical sensors have substantial thermal conductivity. If highly localized measurements are desired, the heat conduction through the metal may defeat the measurement because of conduction of heat from other regions to the sensor. Typically, it has been assumed that this effect would be small, particularly where the leads are of very fine wire and are in good thermal contact with the medium being measured.

However, recent experiments by Lyons, Samulski, and Britt at the Stanford University Medical Center in conjunction with medical hypothermia applications have shown that "smearing" or averaging effects produced even by very small metallic conductors is appreciable. In one of their experiments, two concentric water baths, one at 35 °C and the other at 44 °C were separated by an insulating styrofoam barrier. A small catheter was positioned to penetrate the styrofoam barrier. A thermocouple needle was used to measure the temperature as a function of position. The resultant measurement asymmetry is indicated by the squares in the figure below. While the initial experiments utilized a 22-gauge (0.029 in. OD) needle, later experiments showed similar effects for 29-gauge (0.011 in. OD) thermocouples. The distances shown relate to the dimensions of the styrofoam container.

### The Solution:

A standard Fluoroptic® probe was used to measure the temperature in the same apparatus. Because of the low thermal conductivity of the optical fiber, a highly symmetric measurement as shown by the circles in the figure below was obtained. It can be seen that differences of as much as 1 to 2 °C are observed between the two sets of data. Such errors could be serious in hypothermia applications. An awareness of these effects may be important in other applications as well – particularly where strong temperature gradients are present.



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