Introduction:

The purpose of this report was to review and analyze different methods for determining the thermal time constant, (τ), in water, of different thermocouple temperature sensors. All thermocouples were exposed to a step change in temperature, either from boiling water to an ice bath or from an ice bath to boiling water. To determine the start time of the response due to the change in temperature, we used two unique methods. The first method was defined by the time corresponding to when the temperature differed by more than 5 standard deviations from the baseline temperature. The baseline temperature is defined as the temperature values recorded before the transition took place. The maximum slope onset method, which we found to be more accurate, involved finding the time corresponding to the maximum slope of the temperature vs. time data. Figure 1 demonstrates the higher accuracy of the maximum slope onset method vs. the 5σ onset method.



Figure 1 Bare Wire Thermocouple Transition from boiling water to ice bath. (a) 5σ onset method; ln(Γ) vs. t best fit method to calculate τ. (b) Maximum slope onset method; ln(Γ) vs. t best fit method to calculate τ.

Using each separate onset time, we determined the time constant by finding the time it took the temperature to reach 63.2% of the final value, as well as finding the linear regression of ln(Γ) vs. time, knowing that the slope (a­o) is inversely proportionate to the time constant (equation 1). The relationship between gamma (Γ), the time constant, Tinitial, and Tfinal is shown in equation (2). We found in general, the more precise (exact) way to determine the time constant, was by using the maximum slope onset method in combination with finding the best fit slope of ln(Γ) vs. time.

(1)

(2)

We concluded the accuracy of each analytic procedure (to find the time constant) by comparing plots of the residuals vs. time, as well as relating the actual data to the prediction (*resulting from any given procedure*), by comparing standard errors of the fit.