Improving Process Temperature Measurements

A common misconception when trying to improve temperature measurement is to focus on accuracy. In the case of thermocouples the knee jerk reaction is to change the accuracy from standard to special limits (while remaining with the initial calibration). Special limits cut the accuracy in half for non noble metal calibrations.

There are a few problems associated with this approach. First the measuring or controlling instrument may not be able to read or control the improved accuracy; consequently there may be a cost to upgrade the instrument part of the measurement loop. Second the cost for upgrading to special limits may be prohibitive. Third, the repeatability, which we will define as the ability of the thermocouple to reproduce a consistent output under the same process conditions, may provide the desired results at a lower cost.

The other option when considering accuracy only is to change the calibration. Thermocouple accuracy or inaccuracy is attributed to the inhomogeneities in alloy composition. The optimum thermocouple configuration is to match two pure element legs. Noble metal combinations of gold versus platinum and platinum versus palladium can provide accuracy improvements ten times greater than non noble metal configurations, but are extremely expensive.

What are the alternatives? First let's examine the special limits accuracy of the most commonly used sheathed thermocouple calibration.

Calibration: ANSI type K
Positive Conductor: Chromel
Negative Conductor: Alumel
Accuracy @ 500 degrees C
Special Tolerance: + or – 2 degrees C

In the above case we can assume that the millivolt out put of a type K thermocouple with special tolerance put in service at 500 degrees C will read no lower than 498 or no higher than 502 degrees Centigrade. This produces a four degree uncertainty. Cross Calibration is an option available to improve loop accuracy without incurring all the expense associated with special tolerance calibration. For the purpose of this examination we will assume that identical thermocouple calibrations are involved.

Two areas particularly warrant Cross Calibration consideration, they are:

1. Multiple identical thermocouples installed close to one another in the process or multiple thermocouples that share the same process environment

2. Multiple thermocouples located in the same protection tube commonly referred to as multi-point assemblies.

How does Cross Calibration work?
As stated earlier thermocouple accuracy is dependent on alloy composition. Consequently thermocouples made from the same alloy composition have identical inaccuracies. Identifying the error from a single alloy composition batch assures the user that all thermocouples made from that batch have a repeatable error. In many cases error compensation can be accomplished in the instrument that processes the millivolt signal from the thermocouple.

Why does Cross Calibration work?
Quite simply thermocouples can experience the same degradation when exposed to the same process conditions. This is particularly relevant in multi-point assemblies responsible for reporting reactor temperatures. In the case of sensors not in close proximity the use of analytic redundancy (see footnote) correlations may help the user to understand how to optimize accuracy.

Of course the ability to measure the millivolt output of the thermocouple in a controlled environment is essential in order to employ Cross Calibration.

Contact Smart Sensors and inquire about our calibration lab. Measurement error of thermocouples in our lab can be up to 5 times greater than ANSI accuracies and is NIST traceable.

Analytic Redundancy
Yung, S.K. and Clarke, D.W. "Local Sensor Validation," Measurement and Control, Vol. 22, June 1989, pp. 122-130.

Improve Accuracy – Reduce Noise

Sensor accuracy can be affected by interference from common industrial noise sources. Thermocouple and RTD outputs are low level signals. The thermocouple produces output in millivolts, while the RTD produces a very weak resistance signal. Ungrounded thermocouples, where the conductors are insulated from the sheath can provide protection from some noise sources. The RTD is inherently isolated. But at times radio frequency and electro magnetic interference from walkie-talkies, transformers, motors and power wires can still cause erratic signals even if the sensor is ungrounded or isolated. Converting the output to 4-20 milli-amps by using a field temperature transmitter can reduce noise problems. Smart Sensors offers a transmitter that provides RFI and EMI protection. More importantly all of our field transmitters are isolated. Isolation protects against power surges or errors associated with ground loops.

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