Application Note

Controlling Thermocouple Calibration Errors Caused by Thermal Shock

Cold junction temperature sensing is the Achilles heel of temperature measurement.

When thermocouples are wired directly to control instrumentation, it is often the instruments' thermal behavior which limits performance. Excessive warm-up times and poor repeatability are common. When the effective cold junction is at the input terminals of an instrument, measuring its temperature accurately requires the Cold Junction Temperature (CJT) sensor be located very close (in a thermal sense) to those terminals. The successful measurement of temperature by an instrument using a thermocouple is dependent upon three things:

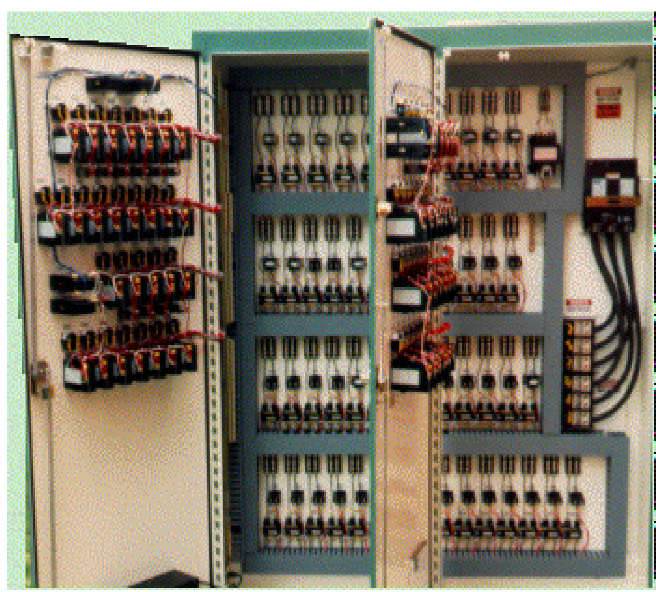
- Location of the thermocouple 'Hot Junction' relative to the load or work being processed,
- Accuracy, drift and calibration of the measurement electronics, and,
- The ability of the cold junction sensor to properly measure the CJT, Cold Junction Temperature.

Often, locating the hot junction of the thermocouple at the work is a simple or easily understood task. Accuracy, drift and calibration of the measuring electronics is clearly specified in instrument data sheets and can be maintained. Successful CJT measurement is another story. CJT measurement is based on many factors, some of which are based on the mechanics of the rear of the instrument. The location of the CJT sensor, the thermal mass of the entire instrument and changes in the local ambient temperature all affect the cold junction temperature measurement. These uncontrollable characteristics of the CJT circuit account for why 'CJT sensing is the Achilles Heel of temperature measurement'.

The Problem

Routine maintenance of control cabinets is a common occurrence. It is an accepted practice to open a control cabinet to check the state of a relay coil or replace a blown fuse or even retrieve a misplaced tool or blueprint. It is also common to air-condition a control cabinet to prolong the life of the electronics.

Consider what happens when an air-conditioned control cabinet is opened on a hot summer day. When closed, the cabinet temperature is controlled to around 65 degrees F. The outside room temperature on a hot August afternoon can easily exceed 110 degrees F. Conventional temperature transmitters are mounted in the control cabinet. When the door is opened, the temperature transmitters are exposed to the 110 degree room air and a 45 degree F thermal shock. This thermal shock alters the Cold Junction Temperature and, more importantly, the ability of the CJT sensor to accurately measure the CJT. In short, the transmitter is out of calibration until it returns to equilibrium. The amount of calibration error and the settling time varies with the instrument. Some transmitters are very quick to respond while others with high thermal mass are quite sluggish.



Thermal shock alters the Cold Junction Temperature and, more impartantly, the ability of the CJT sensor to accurately measure the CJT.

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Some transmitters only deviate by a small amount while others with loosely coupled CJT sensors may have 5 or even 10 degree excursions before returning to an accurate reading.

What makes this situation much worse is that the calibration error is not apparent to the operator. Quite often, the instrument's signal will be used to control the process to this new offset value which is in fact in error. Simply put, the instrument is out of calibration and nobody knows.

The Solution

The Q48Xia Series of temperature transmitters uses a patented dual sensor method for measuring CJT. This technique, called Instant Accuracy, uses two CJT sensors. One measures the CJT near the rear terminals of the instrument while a second sensor which allows the instrument to extrapolate out to the actual rear terminals themselves. In this way, the CJC network can compensate for any heat flow temperature error and respond very quickly to internal warming affects as well as external influences. This extrapolation makes the Q48Xia Series highly responsive to ambient temperature changes and also provides rapid recovery to stability.

Granted, there is some calibration shift as a result of a change in ambient conditions; this is caused by the imperfect nature of the Cold Junction Compensation and is specified in the data bulletins for the products. Recovery time from thermal shock is often not specified, however.

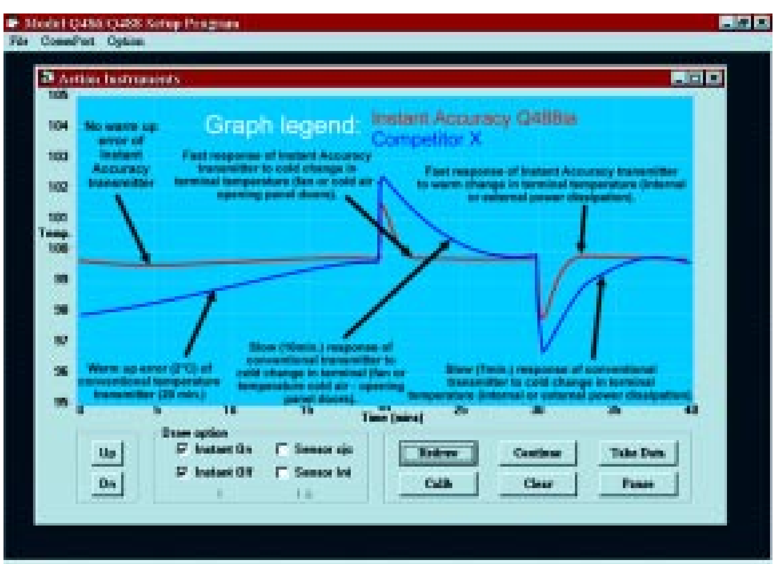
Testing Action's temperature transmitter by introducing a 25 degree C thermal plunge resulted in the following: the peak excursion was 1.15 degrees C but settled within 15 minutes at the final offset value of 0.6 degrees C.

Anyone in charge of a process which must be controlled to within 2 degrees F must be keenly aware of this phenomenon.

Even the best competitive instrument tested was found to be still settling after one hour and the maximum excursion was almost 2 degrees C. The worst instrument tested exhibited an excursion of over 5 degrees C as a result of a 25 degree C thermal plunge.

Conclusion

In short, the thermal plunge associated with opening a control cabinet door can have a major effect on product quality for critical processes. The most devastating aspect of this is that the transmitter appears to be functioning properly with no ill effects whereas, in fact, it is out of calibration and producing substandard product.



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