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Tips for a Better Temperature Calibration

It's well known that temperature is the most common process variable measurement. These measurements are performed by thermocouples (T/Cs), resistance temperature detectors (RTDs), filled systems, non-contact infrared thermometry and by other means.

Of these, the most common on-line measurements are by T/Cs and RTDs, either directly connected to the process control system or data acquisition system or indirectly connected by the use of a process transmitter.

Generally speaking the T/C or RTD being a primary element cannot be calibrated (adjusted). They're either working properly or not. They can be certified, if needed. This type of certification requires a device such as a temperature bath or "dry well" temperature calibrator. But, we're not going into that procedure here.

There are a few "gotchas" in temperature calibration when we're talking about T/Cs and RTDs. Each has its own problems, which we'll discuss separately.

First, thermocouples. Thermocouples work on the principle that two dissimilar metals will generate a small voltage (EMF) proportional to the temperature difference between the "hot" junction where the measurement is made and the "cold" junction where the measurement is observed.

That brings us to the first potential problem. You can only find out the hot junction temperature if you know the cold junction temperature. In the old days, temperature calibrators were simple millivolt generators. The technician could look up the EMF value for a given temperature, use a local mercury thermometer to measure the cold junction temperature, perform a little math (adding or subtracting the EMF for the cold junction value) and come up with the correct simulation value. A similar process could be used to make a temperature measurement.

Today's temperature calibrators all have what's called automatic cold junction compensation. They also do all the "looking up" of EMF values, etc. It makes it easy and usually quite correct. With a few exceptions. If the instrument being calibrated also has automatic cold junction compensation and and the calibrator's automatic cold junction compensation is active, you're in business. If either is not the case, you calibrate in an error equal to the difference between ambient temperature and 0°C. That can be quite a lot. So, it's worth checking to see what's what.

A quick tip about this. If the calibrator has been moved from a relatively warm place to a cold place or vice versa, it may require some time for its cold junction compensation to stabilize for accurate performance.

By far the most common error in calibrating thermocouple instrumentation is the failure to use thermocouple extension wire that matches the thermocouple in question when connecting the calibrator to the instrument. Why? Because the calibrator is measuring a cold junction at its terminals. If copper test leads are used, the actual cold junction will be where the copper leads connect to the instrument. Whatever temperature difference there is between these two points will be calibrated into the instrument as an error. If the two are really close together, it may be small, but why not do the job right? Also, many modern calibrators are designed to use miniature thermocouple plugs and jacks to connect, which makes it really easy to use the right materials.

If you think this is trivial, let me tell you that I have seen technicians connect a calibrator located in front of a control panel to an instrument located inside the panel with looooong copper leads. I'm sure that resulted in an error of 5-10°C. Considering that many processes have tolerances of 1-2°C, that's going to cost a lot of money.

So, two things to remember when calibrating T/C instrumentation: one, make sure automatic cold junction compensation is enabled on both the calibrator and the instrument, and, two, use thermocouple extension wire that matches the curve of the thermocouple to connect the calibrator to the instrument. Today's smart temperature calibrators make the rest easy.

RTDs are a different animal. An RTD works on the principle that the resistance of a metal wire increases proportional to increases in the temperature of the wire. They're very accurate and reliable when properly applied.

In use, there is a very small coil of fine platinum wire at the tip of the RTD. This is the actual sensing part of the device. Then, two, three or four copper wires are attached to that coil to extend the measurement to the end of the enclosing metal sheath. If two wires, they're connected one to each end of the coil. If four wires, they're connected two to each end of the coil and if three wires, they're connected one to one end and two to the other.

Why the extra wires? Accuracy of measurement. Since we're making a resistance measurement to be interpreted as temperature, we don't want to also measure the unknown resistance of the wire between the little sensing coil and wherever we connect our measuring instrument. Therefore we have compensating leads, which allow us to cancel out the resistance of the connecting wire.

The only thing we really need to worry about when calibrating an RTD sensing instrument is to match up to the type of connection the RTD uses. If the RTD uses three wire, then the calibrator should be connected to the instrument with three wires. That's one tip. Again, depending upon how everything is connected, using two wires may only introduce a small error. Why not do it right? Even if you have to play around with connections for a couple of minutes to get it right, do it right!

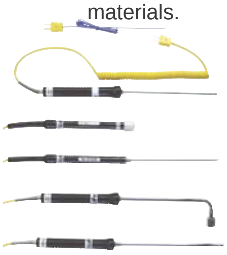
A second difficulty that can arise with RTD instrumentation is caused by the need to keep the excitation current for the RTD at a minimum. This is done both to allow for very low power operation and to prevent self-heating of the RTD element (toaster effect). Low power may mean turning the excitation current to the RTD on and off according to some pattern. The calibrator must detect this pattern and match it.

Why, you say? It's one of the dirty little secrets of modern resistance calibrators. There's no actual resistance involved. Instead, the calibrator is measuring the current flowing to the sensor and calculating the voltage drop that would be generated by a certain temperature at the sensor. Whoa! A little Ohm's law work and you can make the instrument think there's a resistance by applying an opposing voltage. Clever and it works in most cases. Some calibrators do a better job than others in tracking the small pulsing excitation current and thereby doing a better job of faking the resistance.

If you observe instability in the resistance simulation, this pulsing excitation current is likely the problem. Either find a calibrator that can handle it or fall back on the trusty true resistance solution, a decade box.

Modern temperature calibrators really make it easy to perform quality accurate temperature calibrations. Watch out for these tricky mistakes and you'll do fine. Good luck!

By:
Bill Modlin, V.P., International Sales
MARTEL Electronics Corporation, Beta Calibrators Division



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