

Calibrating and Testing Control Components on Your Heat Process.

What, when and how should I calibrate?

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You want your processing to be accurate, consistent and reproducible over the long term.

You want to be ready when ISO compliance or your customer's quality control calls for proof of the integrity of your operation.

So make sure all your process-critical signals are checked and recorded once or twice per year.

Some but not all process variables have to be accurate to get the demanded quality, yield, safety and energy efficiency. For optimum cost and efficiency keep in mind where best to apply your diligence and tight tolerances.

Calibrator

Your test equipment list.

1. A precision multi-function signal source (also called a **calibrator**). This will put out precise (0.1% or better) voltage and current signals that simulate the outputs of various devices e.g. thermocouples, RTDs and transmitters. Besides simulating these devices they can measure their outputs and present the indications in engineering units.
2. A **run-up box**. This is little box with a pair of dc output terminals. It contains a battery, a fine and a coarse potentiometer and a few resistors. You can make one yourself. It is used to inject a signal into an instrument or process to run it up and down for a quick test without involving calibration. You can also buy products with varying levels of price, performance and features ranging from the run-up box to the precision calibrator.
3. Precision multimeter.
4. Clamp-on ammeter.
5. Flashlight, schematics and manuals.
6. Clipboard or pre-printed forms for your records.
7. An adjustable temperature source for calibrating temperature sensors.

Items to check and calibrate.

Thermocouple or RTD actuated temperature indicators, recorders or controllers. Leave the instrument on the bench, switched on and connected to the calibrator using the correct extension cable. With RTD instruments use copper wire. Wait 10-20 minutes for both to attain room temperature. Inject a minimum of four signals spread through the useable range plus one near your working temperature. Record the indications as found - and as left if you make any calibration adjustments.

The working environment of an instrument may be a few tens of degrees different from that on the bench. If you suspect that the calibration performed at the two locations do not agree, calibrate first at the working location then on the bench at normal room temperature.

I have dealt in a previous column with the problems of perfectly good instruments and thermocouples combined with mismatched or misconnected thermocouple extension cable.

This brings stealthy errors that can come and go within minutes or hours. You may detect these by calibrating on site and injecting the calibration signal into the extension cable at the thermocouple head,

having first disconnected the thermocouple.

Say you are calibrating an RTD actuated instrument on the plant from the sensor location. You are adding (usually three) wires into the circuit that were not there at the bench calibration. If the wires have equal resistance, say as in a three-core copper cable, you will get the same result as a bench calibration. Any unbalance in the sensor wiring can introduce measurement errors. Check the instrument specification for the effects of resistance and resistance unbalance.

Alarm settings. After you have calibrated your instrument use your run-up box or calibrator in ramping mode to check where alarms trip in relation to their settings. Check dead zones too by approaching slowly from below and above the settings.

Temperature transmitters and signal conditioners. The same principles apply as for indicators. Inject the simulated process signal at the input. You will not usually have an indication. You are looking for a linear dc output (e.g. 4 – 20mA) corresponding to the temperature range of the intended sensor.

Connect your precision multimeter to the output and compare a range of precise input signals with their corresponding analog output signals. Remember that some low cost transmitters and signal conditioners reproduce any input non-linearity (e.g. from thermocouples) at the high level output.

Retransmission signals from controllers etc can be treated like outputs from transmitters and signal conditioners but you have to compare these outputs with the values in the controller that they represent. E.g. Process temperature, set-point, deviation from set-point or percentage output.

Advanced features of calibrators.

Some advanced calibrators can:

- Ramp the output up and down at a controlled rate.
- Inject and display an input signal and display the output of the device under test at the same time.
- Capture data in memory for uploading through a PC interface for archiving, printing and analysis.

Note that the calibrator cannot see and capture plant instrument indications. You still need to read by eye and write or key them in.

- Calibrate and configure Hart communicating transmitters. These carry a digital signal riding on the analog output signal wires.

Control signal and temperature sensor calibration.

Control signals are put out by controllers and expect to be obeyed by such final control devices as motorised valves, electro pneumatic valves, motor drives and SCR heater controllers. How well they are obeyed is often pretty rough and non-linear. Checking at this stage while not called calibration is important to control performance.

You can inject simulated control signals into these devices and see what the output does. Be wary about what their feedback signals (if any) represent. They will likely be linear mimics of the control signal rather than a measure of what you are trying to deliver, e.g. fuel flow or electric power. You may be more assured by noting valve travel, dead zone, fan speed, heater current etc but this will not amount to a proportional delivery of heat. With electroheat you can use an accurate clamp-on rms ammeter to check your heater ammeters. Then you can do a quick I^2R calculation to determine heater power given that heater resistance is reasonably constant.

Calibration of temperature sensors is done much less frequently than calibration of instruments. It can be slow and tedious but no less important.

Sensors are usually replaced only when they burn out or break. As their calibration drifts over time,

operators sometimes adapt instinctively by adjusting controller set-points to maintain good results or product. The revised settings will not be reliable when the sensor is replaced.

The two wires inside a thermocouple may come together, sometimes intermittently, some way back from the hot junction and the controller will receive a reduced signal. The controller will respond and turn up the temperature but will not show the increase. It takes an alert operator or an independent alarm device to detect overheating.

Plants that use more than one type of thermocouple may put in a spare thermocouple or plug in a spare controller that is a mismatch. During maintenance an interchange of type J and K is not uncommon, and the indications are not wildly different.

Check critical sensors once or twice a year at their working temperature. Tag them with the type and any known calibration errors.



A **liquid bath calibrator** is a common choice up to 250 °C (480 °F).

A **dry block calibrator** (a heated metal block with deep holes for the sensors) is useable up to about 600°C (1112°F)

A **fluidised bed** of alumina particles can be used up to some 1100 °C (2012°F). Up to about 1600 °C (2912 °F) specially designed furnaces are used. The temperatures are controlled using a platinum RTD or a platinum/rhodium thermocouple.

Sensors with a heavy metal protection tube can pull heat out of the calibrator and may have difficulty reaching the exact temperature indicated by the controller. Insert the sensor deep and if practicable remove the tube. Make sure that all of the wire-wound sensing section of an RTD lies deep in the hot zone.

Dry Block Calibrator

IR (Infra-red) thermometers.

These can lose accuracy due to targeting misalignments, emissivity changes and dirty lens or sight path. Fix what you can with targeting and cleaning then if you can get a thermocouple onto the target, read its true working temperature. Trim the emissivity adjustment on the IR instrument to make its reading agree with that from the thermocouple.

General Comments

- Replace instruments that show an unacceptable spread of dancing digits when being calibrated. When in service you can expect some instability from fast moving signals without attributing it to interference or defect. Signals from temperature sensors are usually calm and slow moving.
- For analog indications check for **dead band** (also called hysteresis) by taking the signal slowly up to and down to the check point. This will reveal bad pivots on meters and excessive friction on recorder or other servos.
- Note that digitally positioned, non-servo chart recorders and paperless recorders have no slidewires or other position feedback devices and do not suffer from dead band.
- Consider using a well-established instrumentation service company that has invested in trained technicians and accurate NIST traceable test equipment.