HOW ACCURATE IS THAT PROBE?

At Hart, we field inquiries every day about reference thermometers. Inevitably, as a particular thermometer is discussed, the same bottom-line question is asked: “How accurate is it?”

The purest metrology answer to this question is, at best, disconcerting: “Nobody knows until you re-calibrate it—*after* you’ve used it.”

While this is probably the best answer that can be given, it’s not very helpful when you’re trying to select the right thermometer. So if you’d like an idea of accuracy *before* you buy a thermometer, here are five things to consider.

Calibration

One of the most important contributors to the accuracy of your reference thermometer is the way it was calibrated. All calibrations are not equal.

Calibrations by fixed points are generally better than calibrations by comparison. Calibrations limited to a narrow temperature range are better than calibrations done over a needlessly wide range. Calibrations by people who know what they’re doing are better than calibrations by people who don’t.

Your calibration should describe the method used, state the uncertainty or test-uncertainty-ratio of the calibration, include a calibration report that meets your quality standards and demonstrates traceability to a national laboratory, and be done by an accredited lab or company you trust. The uncertainty of your probe’s calibration is the first element of accuracy to consider.

Short-Term Stability (Repeatability)

Just because your thermometer has been well calibrated doesn’t mean it repeats each identical measurement perfectly. Limitations on the abilities and physical purity of the sensing element and other materials used in the construction of the thermometer prohibit perfect repeatability.

Different types of thermometers made by different manufacturers have varying susceptibilities to errors from hysteresis, oxidation, and other sources of instability. Thermocouples, for example, are inherently less repeatable than reference-grade thermistors. Strain-free SPRTs are more repeatable than industrial RTDs. The point is that short-term instabilities cannot be “calibrated out” and must be considered as an additional source of uncertainty.

Long-Term Stability (Drift)

Long-term stability, or “drift,” is a critical specification for any reference thermometer. Many causes of short-term instability grow worse as a thermometer’s thermal history increases. Normal wear and tear takes its toll on even the best sensing elements and affects their output. It’s important to note that “normal wear and tear,” in this case, should be defined in the specification.

For example, a drift specification may be stated as “less than 2 mK after 100 hours at 661°C” (such as on page 9) or as “±0.01°C at 0°C per year maximum, when used periodically to 400°C” (such as on page 67). If your intended use of the thermometer is more or less strenuous than what the manufacturer states, you may anticipate correspondingly more or less drift.

Many causes of long-term drift can be periodically addressed and, to some extent, removed. The effects of oxidation, for example, can be largely removed by occasional annealing at high temperatures. Annealing, itself, however, adds more high-temperature history to the sensor and should not be done needlessly. One of the reasons the drift specification is so important is that it helps identify how long you can use your thermometer between recalibrations.

Usage

You won’t find a specification to account for all the ways a reference thermometer can be misused (or even abused), but in evaluating specifications it must be understood that the manufacturer has made assumptions regarding how its instrument will be used. At Hart, we tend to write “looser” specifications to allow for instruments being used in less ideal conditions than those under which we use them. Not every manufacturer is so generous.

Typical examples of misuse include inadequate immersion depth, subjection to mechanical or thermal shock, inadequate thermal contact against the subject being measured, use outside the specified temperature range, and extended use at extreme ends of the temperature range. Before assuming your thermometer will perform the way the manufacturer says it will, satisfy yourself that it will be used within the manufacturer’s intended parameters.

Display Accuracy

This point seems almost too obvious to mention, but it’s too important to pass by. The uncertainty of the thermometer’s readout device (bridge, DMM, *Black Stack*, etc.) must be added to the uncertainty of the actual thermometer when considering total accuracy. No electrical thermometer (PRT, thermistor, thermocouple, etc.) generates a direct temperature reading. The resistance or voltage must always be interpreted (and usually linearized), and there are always errors inherent in this process.

In the Final Analysis

In the end, the fact remains that the metrologist is right. You won’t know how accurately your thermometer has performed until you recalibrate it. The moral is simple: consider all the appropriate performance specifications, use the thermometer correctly and carefully, and recalibrate it soon to verify its performance. As recalibrations yield positive results and confidence in an instrument grows, calibration intervals can be extended and maintenance costs decreased. If you’re buying from the right manufacturer and handling your thermometer correctly, you’ll find it not uncommon to experience much better results than what the manufacturer has specified.