

Does immersion depth really matter?

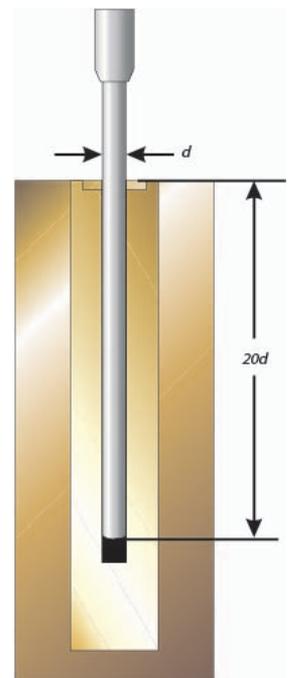
Application note



Making measurements with a temperature probe can be challenging. Imagine contacting your favorite temperature experts at Fluke Calibration and learning that the measurements you have been making for years haven't been working out as well as you thought. Don't worry, you're not alone. The temperature experts at Fluke Calibration are here to help. This application note discusses how immersion depth, temperature range and fit affect your temperature measurements and provides some useful guidelines to help you get the best results from your temperature measurements.

Acceptable immersion depth

Many of us have heard the words "acceptable immersion depth." But what does that really mean? An acceptable immersion depth can vary depending on the situation. For example, the folks in our Primary Standards Calibration Lab will be looking for very deep immersions when they are calibrating a standard platinum resistance thermometer (SPRT) with uncertainties of 1 mK or less. On the other hand, the temperature probe used to monitor the coolant of that combustible engine you've been testing might not need to be so deeply immersed. So how do you know your immersion depth is adequate? Applying a simple rule of thumb can help you decide. For an industrial temperature calibration application, simply multiply the probe diameter by fifteen, and then add the internal sensor length to the result. So, for example, if you have a quarter-inch diameter probe with an internal sensor length of one inch, you would need to immerse the probe to a minimum immersion depth of $(0.25 \text{ inches} \times 15 \text{ inches}) + 1 \text{ inch} = 4.75 \text{ inches}$. If you are working with probes with much lower uncertainties, such as SPRTs, increasing the multiplier to 20 or even 30 is a good idea.



Probe immersion depth and fit are both critical to making meaningful measurements.



Primary standard level temperature measurements require much deeper immersion depths.

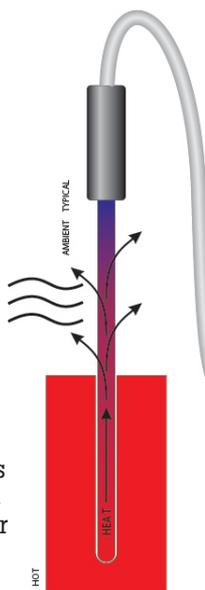
Temperature range

Another concern that arises when measuring short or irregular probes is temperature range. The temperature range of a probe can play a big role. If you expect a temperature sensor to function with some level of accuracy at very high or very low temperatures, you should consider the effects of ambient air on the probe. Think of it as a heat sink. If you have one end of the probe at 500 °F (260 °C), for example, and the handle/fixture portion of the probe in ambient air, you can imagine that the handle or fixture of the sensor will act as a heat sink and possibly alter the measurement you are making. The key here is to understand that the further your temperature of interest is from ambient air, the more likely stem conduction, or “heat sinking,” is altering your measurement.

Fit

The other key issue is fit. A temperature probe relies on the surrounding environment’s ability to convey its temperature to a sensing element. Air temperatures, for example, are some of the most difficult to measure. Air is a very effective thermal insulator, making temperature measurements a bit problematic. If your temperature probe does not make good thermal contact with the temperature source you’re measuring, you won’t get an accurate representation of its true temperature. Minimizing this air gap is critical. In other words, an air gap will act as an insulator

Considering the effects of ambient air on a temperature probe helps to reduce measurement uncertainties.



and will have some effect on the measured results—even if you have followed the immersion depth rule of thumb.

Guidelines for making accurate temperature measurements

What can you do to ensure that the temperature measurements you make are as accurate as possible? Here are some general guidelines:

- Understand how your probe is put together internally. If not specified, it’s a good idea to ask the manufacturer for the sensing element length and its location relative to the probe sheath tip. This information will help you to calculate the proper immersion depth and give you an understanding about which portion of the probe is actually doing the measuring.
- Consider the application as a whole. Look for proper immersion depth, fit and orientation to ensure that you are going to measure as accurately as possible and that you’re measuring what you’re truly interested in measuring.
- What about fit? If you are inserting a probe into a dry-well, for example, you’d expect the probe to fit with as small an air gap as possible. It is possible to get that probe stuck, so use some caution here. When working with probe diameters of 0.25 inches or smaller, you would generally look for a difference of about 0.005 inches between the probe’s outside diameter (OD) and the well’s inside diameter (ID). For larger diameter probes, 0.010 inches is a good place to start.

The next time you reach for that Fluke Calibration thermometer readout and probe, consider the items discussed here and apply them to your unique situation to ensure the best possible results. And remember, if you ever find yourself needing some help, a Fluke Calibration representative is only a phone call away.

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