

Thoughts on Temperature Sensor Sensitivity

Understanding how temperature sensors respond to heat and cold can help with the selection of monitoring systems for critical applications.

One of the most interesting things about temperature monitoring is the continuous need to help folks understand the basic assumptions about the monitoring devices themselves. For example, temperature sensors come in all shapes and sizes, accuracies, ranges of measurement, materials, and with all manner of configurations. But the question comes up quite often, which should I choose?

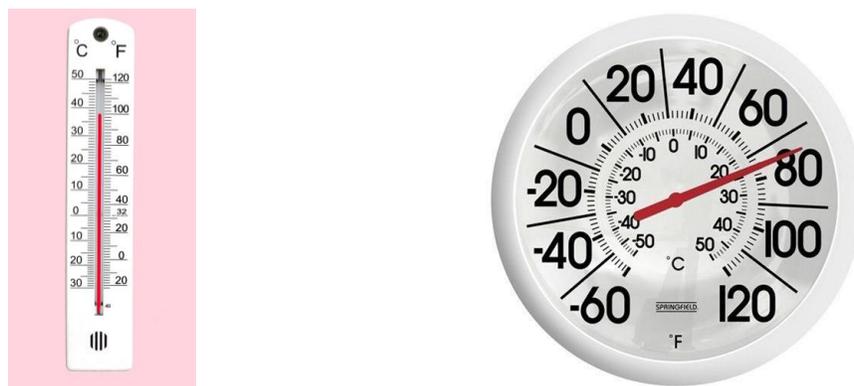
One important thing to note before considering sensor qualities is to remember they will need to operate within specified parameters. For example, the medium being measured (air, water, etc.) must be able to be in intimate communication with the sensor, so in air, the sensor must be surrounded by the air being measured, not shielded or insulated from it. Sometimes things change and the sensor is no longer able to measure the temperature of the medium of interest. A well known example of this type of concern is a household refrigerator's freezer compartment that is not equipped with an automatic defrost cycle, which many of us remember well. In this case the sensor is buried below the ice, so never reads air temperature.



Household refrigerator's freezer compartment with excessive frost build-up.

Each type of temperature sensor has its strengths and weaknesses. One strength or weakness of a temperature sensor is its accuracy, meaning how well it measures temperature to a known, industry approved standard. Another is sensitivity, meaning how quickly or slowly the sensor will react as the temperature changes. Matching the speed of response to the application is important. If you're monitoring an area where temperatures can rise rapidly and quickly endanger the location's contents, fast response is helpful. If, on the other hand the sensitivity is too fast for the application, say when the sensor is in a refrigerator and placed very close to the door, the temperature could rise rapidly but not represent what's going on for the food or medications stored inside. In this case, alert messages could be sent when it's business as usual.

The simplest temperature sensor is the liquid thermometer we're all familiar with, filled with either mercury (hopefully these have been replaced by now) or red dyed alcohol that expands when heated and rises into a thin capillary tube. A scale is incorporated to read the temperature. Another thermometer found in many homes is a metal spring type, typically a coil where the expansion of the metal makes it uncoil when heated and contract or coil up when cooled. Attach a needle to one end and have the needle point to a scale and you're measuring temperature. These "sensors" work quite well for household and human comfort applications. They are reasonably accurate (nominally $\pm 0.5^{\circ}\text{C}$ to 3°C) and respond sufficiently well to temperature changes. Variations in sensitivity and accuracy are related to cost, less expensive ones being on the lower end of accuracy and sensitivity, more expensive ones on the higher end when only the cost of the mechanism (liquid filled tube or spring, accuracy of alignment to the scale) and scale resolution are considered.



Household liquid alcohol filled (left) and coiled spring (right) thermometers

Another type of sensor takes advantage of the electrical property changes of materials when their temperature changes. For electronic monitoring devices these sensors offer the advantage of being able to easily integrate into the electrical circuitry. Such sensors can be an integrated circuit with on-board temperature sensing structures like the ones use by Temperature@lert, or thermocouples that consist of two different metals that react different to the same temperature and the difference can be detected electrically. These sensors are sensitive to small changes in temperature, and are generally accurate to $\pm 0.5^{\circ}\text{C}$ or better.

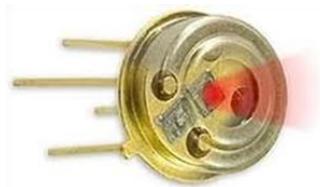


Digital IC Temperature Sensor



Type-K Thermocouple

Other technologies like infrared imaging provide popular non-contact methods, each having its own application niche, particularly where the temperature of a surface is of interest and contact with the surface difficult or impossible. One example would be the temperature of baked goods, say high volumes of cookies or pies as they exit an automated oven. The infrared thermometer can be used to insure the baked goods are at the correct temperature to be completely baked. Calibrating these sensors to the product being measured is a whole science unto itself. [Link to R&D Magazine Article on IR Sensor Calibration Equipment Selection](#)



Infrared sensor for non-contact temperature measurement applications

Each of these devices has its strengths and weaknesses. As noted, one strength or weakness of a temperature sensor is its sensitivity, meaning if something happens the device will react quickly or slowly. Matching the speed of response to the application is important. If you're monitoring an area where temperatures can rise rapidly and quickly endanger the location's contents, fast response is helpful. If, on the other hand the sensitivity is too fast for the application, say when the sensor is in a refrigerator and placed very close to the door, the temperature could rise rapidly but not represent what's going on for the food or medications stored inside. In this case, alert messages could be sent when it's business as usual.

For sensors with good sensitivity, one way to make sure the sensor is not "too sensitive" is to place in into a tube or container that shields it from direct contact with the air and delays the response, not so much that it can lead to problems but enough to avoid unnecessary alerts. One common way to do this is by placing the sensor in a metal tube that's sealed on one end. The metal will conduct heat but delay the response to the air temperature by a small amount. If that is not enough of a delay, say for times when someone needs to keep the refrigerator door open for a couple of minutes in a supermarket, a buffer vial filled with a non-toxic material like sand can provide the necessary sensitivity adjustment.



Digital IC Temperature Sensor Configurations: Exposed sensor on the end of a cable (left); Stainless steel sheathed sensors (two sized sheaths) on the end of a cable (middle); Dry granular material filled buffer vial with sensor attached (right)

In the end, it's about knowing what is important to protect the valuable contents of the area that is being monitored. Need more information? Consult with your environmental monitoring representative or as always, feel free drop us a line or give us a call to discuss this any other issues you may have about environmental monitoring of critical environments.

A more detailed discussion showing results from various sensors can be found in the following White Paper. [Link to Temperature@lert White Paper](#)