Temperature drift in temperature instruments

What is temperature drift? Must it be taken into account during calibration? How can the size of the temperature drift be determined? This article answers these questions and more.

Temperature drift occurs in all electronic devices because the vast majority of their components alter their value to some extent in response to changes in the ambient temperature, including those due to self heating. Temperature drift is expressed as "degrees of change in the measurement value per degree of change in the ambient temperature", e.g. 0.05 °C/°C.

Measurement chains of thermocouples and transmitters or indicators are known to be more susceptible to temperature drift than for example chains of Pt100s. This is mainly because thermocouples have two measuring junctions: one at the measurement object and one at the entrance to the electronic device (the reference junction). The thermocouple's measurement signal is the difference between the two temperatures. The measuring device must itself measure the reference junction's temperature and add it to the thermocouple's signal. First then is the measurement object's temperature related to 0 °C. See page 2, Cold junction.

Calibrate at the operating temperature

How the reference junction's temperature is measured often determines the quality of the entire measurement chain. The temperature sensor measures its own temperature, which means that the sensor must be placed in very good thermal contact with the reference junction.

Measurement chains consisting of Pt100s also exhibit temperature drift even though this can be ten times less than for thermocouple systems. In this case the issues associated with the reference junction do not apply.

A typical source of error often occurs during calibration. If the ambient temperature of the electronic device during calibration differs from the temperature of the device's normal operating conditions, the difference will be included as a measurement error. See Figure 1. For example, a measurement chain with drift data of 0.05 °C/°C will show a measurement error of 0.5 °C if the calibration is done at 20 °C and the normal operating temperature inside the associated control cabinet is 30 °C. In this case you can choose to accept the measurement error or to calibrate at the actual operating temperature, e.g. on the spot during full operation or in a heated chamber.

The best alternative is to place the electronic device in an environment that is close to room temperature. Electronic devices should be calibrated at 23 °C, a requirement at accredited laboratories. In existing control cabinets the interior space can be better ventilated and the electronic device can be placed away from heat sources. For a transmitter inside a sensor's terminal head one can extend the neck or shield the head from the radiant heat. See Figure 2 on page 3.

Ask the sales associate

In the case of mobile measurement equipment, the ambient temperature can vary more – e.g. inside/outside, summer/winter, refrigerated/heated chamber etc. As a result, the temperature drift is often more difficult to deal with. Either you must use different pieces of measurement equipment for the different temperature ranges or you must sacrifice accuracy and include large measuring ranges, which will lead to significant measurement errors, see Figure 1. A third solution, of course, is to go to the expense of buying indicators that have an extremely small temperature drift. On the other hand, the most stable instruments are not always designed for use in the field.

In the optimal situation, the data sheets will clearly state the measuring device's temperature drift. Sometimes the data sheets state some kind of maximum error that includes several different components. In this case the temperature drift is not apparent. Instead, you must ask the source that sold you the device and hope they can obtain the information for you.

Typical values of the temperature drift in measuring circuits for thermocouples can range from 0.1 down to 0.005 °C/°C. Typically the value is 0.05.

In the case of Pt100 circuits the temperature drift typically involves values that are ten times lower. There are laboratory versions that have a drift of only ten-thousandths of a degree. As usual, the cost of these increases in direct proportion to their increased performance.

Calculate the drift

It is also possible to calculate the temperature drift yourself. See Figure 2. Measure with and read from the instrument that is to be tested a reference temperature T_{ref-A} / T_{ref-B}, (e.g. in an ice bath). Do this both when the instrument is at room temperature T_{amb-A} and when it is in a refrigerated chamber T_{amb-B}. Let the instrument become thoroughly temperature equalised in both cases, e.g. in a refrigerated chamber overnight. To measure T_{amb-A} and T_{amb-B} you can use a second indicator with an attached thermocouple wire that is taped to the test object's casing. This other indicator must always be at room temperature.

The drift in °C/°C can be calculated as follows:

$$\text{Drift} = (T_{ref-A} - T_{ref-B}) / (T_{amb-A} - T_{amb-B}) \qquad (1)$$

Keep in mind that the temperature drift data reflect stationary conditions, that is, the properties of the measuring device after it has experienced a long period of temperature equalisation. In Pentronic's laboratory, for example, this equalisation is done over a 24-hour period and the device is then operated for two hours prior to calibration.

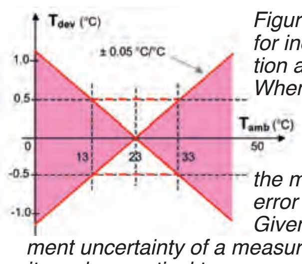

Figure 1. In principle, for individual calibration at 23 °C, T_{dev} = 0. When measuring in deviating temperatures $T_{amb} \neq 23$ °C the measurement error T_{dev} increases. Given the measurement uncertainty of a measurement system it can be practical to encompass the entire temperature range in which you plan to use the measurement system. In this diagram the range is 23 ± 10 °C for which the measurement uncertainty is regarded as a constant ±0.5 °C.

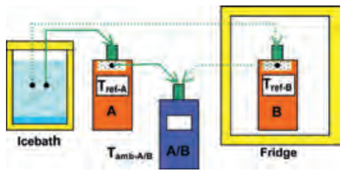

Figure 2. Calculating the temperature drift in a thermocouple indicator (orange).
A) Read the ice bath temperature T_{ref-A} with the indicator at room temperature T_{amb-A}.
B) Read the ice bath temperature T_{ref-B} with the indicator at the refrigerated chamber temperature T_{amb-B}. The temperatures of the ice bath and the refrigerated chamber are taken using another measurement device (blue). Calculate the temperature drift by using the equation (1) in the text.

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