How to improve the total uncertainty of the calibration with a temperature dry-well calibrator (industrial applications)

WIKA data sheet IN 00.32

For some calibration teams the uncertainty of a temperature dry-well calibrator, indicated in the data sheet, is not enough. There are solutions available to improve these values which are explained explained in this document.

Calibration is essential to establish and maintain the accuracy of any thermometer. It can be used to provide traceability to national standards and compliance with quality systems such as ISO 9000. Comparison calibration is achieved by immersing thermometers in a stable temperature environment together with a reference thermometer.

The choice of calibration instrument depends, alongside the temperatures, on the type of thermometer used in the process. For sensors with equal and common geometry, a temperature dry-well calibrator is the ideal solution. In these cases, you can make an optimised adaption of the bores in the insert (minimum immersion depth: 70 mm) and reduce the uncertainties.

For an accurate calibration, the thermal coupling of the temperature sensor to the block and insert is crucial. With too large a bore diameter, the air gap between the bore wall and the sensor diminishes the heat transfer. Longer settling times and measurement errors are the result. A clearance of 0.5 mm is considered to be a compromise between still-acceptable measurement errors and the risk of the probe becoming jammed.

CTD9300 as an application with an external reference thermometer

Since all temperature dry-well calibrators are closed at the bottom and open at the top, this inevitably results in an axial temperature gradient in the block and insert. This leads to measurement errors if the test item is not seated on the bottom of the sleeve. As gradients over the first 40 mm above the bottom provide the largest contribution to the measurement uncertainty, these are therefore also specified in the data sheets. If the measuring point of the test item is outside this zone, the calibration is further distorted by an “axial inhomogeneity error”.

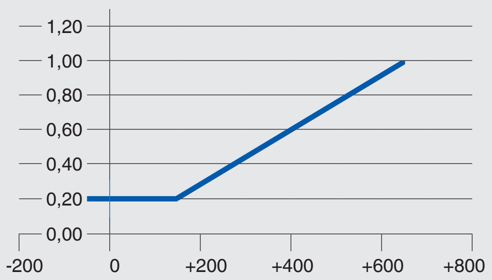
If test items cannot be inserted down to the bottom of the sleeve, you should use an external reference thermometer. Then, the reference and test item can be aligned to the same temperature gradients. The inhomogeneity error is thus largely compensated for and the measurement uncertainty significantly reduced.

But not only can this issue guide the customer to use an external reference. The most important topic is the accuracy. This will be highlighted on the following page.

The deviation of temperature dry-well calibrators from WIKA is defined in the range -55 ... +650 °C as 0.1/0.15 K or 0.1/0.15 % of reading, whatever is greater. To trust the value on the display and to trust the accuracy, the calibrator needs a traceable certificate. If a new calibrator is calibrated and adjusted in WIKA's temperature DAkkS laboratory, WIKA can reduce the deviation to ZERO and the total uncertainty is only the measurement uncertainty of the laboratory.

Due to different parts of the measurement uncertainty budget the measurement uncertainty of accredited laboratories is nearly the same.

Total uncertainty dry-well calibrators



Temperature dry-well calibrator model CTD9100-165

Precision thermometer model CTR5000 with multiplexer model CTS5000

If for some applications the measurement uncertainty of > 0.2 K is not good enough, WIKA are able to provide a range of equipment: e.g. a temperature dry-well calibrator in combination with a precision thermometer and temperature probe.

The ASL's range of precision thermometers provides a with the ultimate in performance and measures resistance ratio against a high-stability internal standard resistor. Comparison calibrations of platinum resistance thermometer (PRTs) typically involve measuring the resistance of the unknown thermometer after first determining the dry-well temperature with a reference thermometer. Both measurements are referenced to the same internal precise standard resistor. With the “direct comparison” technique, the reference thermometer is used in place of the standard resistor and the ratio of the unknown probe resistance to that of the reference thermometer is measured directly.

The deviation of such precision thermometers is defined in two parts:
deviation of the electrical instrument itself + deviation of the temperature probe = deviation of the measuring chain

Therefore the uncertainty of the laboratory has to be added to the deviation of the measuring chain to calculate the measurement uncertainty, for example:

Model	Δ	Δ_{probe}	U_{lab}	Total U
CTH7000	0.015 K	0.01 K	0.01 K	0.035 K
CTR5000	0.005 K	0.01 K	0.01 K	0.025 K

Best case: $\Delta_{probe} = 0$ K
Worst case: $\Delta_{probe} = U_{lab}$

To achieve the best performance of the precision thermometers the coefficients/characterisation of the temperature probe has to be calculated and stored in the instrument channel being used or if using SMART probes into the probe connector.

WIKA recommends using an external reference in combination with a temperature dry-well calibrator up to a temperature of 500 °C for the following reasons:

- Different shapes of devices under test can be calibrated
- Improve the accuracy up to 95 %
- Flexible use for other applications
- The calibration is performed on the reference thermometer, the temperature dry-well calibrator does not require a calibration

Outlook

To achieve a better result for the deviation of the temperature probe, we recommend calibrating the precision thermometers using the fixed point method. The freezing, melting or triple points of specific pure materials are used to define the fixed reference temperatures that are used in ITS90 (international temperature scale of 1990). This improves the measurement uncertainties of laboratories to approx. 1 mK.

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