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

For some calibration teams, the uncertainty of a temperature dry-well calibrator, indicated in the data sheet, is not enough. The available solutions to improve these values are 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 assurance systems such as ISO 9000. Comparative 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 probes with equal and common geometry, a temperature dry-well calibrator is the ideal solution. In these cases, the bores of the insert can be optimally adapted (minimum immersion depth: 70 mm [2.75 in]) and the measurement uncertainties reduced.

For an accurate calibration, the thermal coupling of the temperature probe to the dry well and insert is crucial. With too large a bore diameter, the air gap between the bore wall and the probe diminishes the heat transfer. Longer settling times and measured errors are the result. A maximum clearance of 0.5 mm [0.02 in] is considered to be a compromise between still-acceptable measured error and the risk of the probe becoming jammed.

CTD9350 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 dry well and insert. This leads to measured errors if the test item is not seated on the bottom of the sleeve.

As gradients over the first 40 mm [12.58 in] above the bottom provide the largest contribution to the measurement uncertainty, these are therefore also specified in the data sheets.

If the measuring location 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 gradient. The inhomogeneity error is thus largely compensated for and the measurement uncertainty significantly reduced.

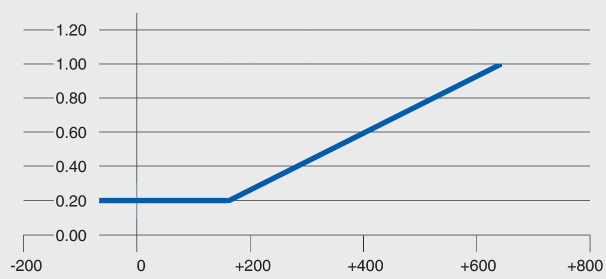
Further technical information:
Fixed-point calibration per ITS-90; see IN 00.38

But not only can this issue guide the customer to use an external reference. The most important topic is accuracy.

The deviation of WIKA temperature dry-well calibrators depends on the model and temperature range used. 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 configured in WIKA's DAkkS temperature 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 of dry-well calibrators



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

WIKA's precision thermometers offer maximum performance and measure resistance ratios against an internal high-stability reference resistor.
Comparative calibrations of platinum resistance thermometers (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 precision reference resistor. With the “direct comparison” technique, the reference thermometer is used in place of the reference 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 steps:
Deviation of the electrical measuring 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 in order 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
CTR3000	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 possible performance of the precision thermometers, the coefficients/characterisation of the temperature probe have to be calculated and stored in the measuring instrument channel being used (or if using SMART probes into the probe connector).

Precision thermometer model CTR3000 with multiplexer model CTS3000

WIKA recommends using an external reference in combination with a temperature dry-well calibrator up to a temperature of 500 °C [932 °F]. The reasons for this are as follows:

- Different shapes of instruments to be tested can be calibrated.
- Accuracy can be improved up to 95 %.
- Flexible use for other applications.
- The calibration is performed with the reference thermometer, the temperature dry-well calibrator does not require a calibration.

Temperature dry-well calibrator model CTD9100 with precision thermometer model CTR3000

Outlook

To achieve a better result for the deviation of the temperature probe, we recommend calibrating the precision thermometer 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 ITS-90 (International Temperature Scale of 1990). This improves the measurement uncertainties of laboratories to approx. 1 mK.

→ For information on the fixed-point calibration in accordance with ITS-90, see technical information IN 00.38 at www.wika.com.

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