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Calibrations up to double precision

No two calibrations are absolutely identical. Take temperature measuring instruments, for example: the test method chosen for thermometers and sensors is influenced by process conditions, quality standards and safety requirements. The device to be calibrated may be attested up to double precision depending on the method. This can be a crucial factor when endeavouring to maximise process efficiency.

Temperature is measured more often than any other parameter in industrial processes. Unsurprisingly, therefore, a large number of thermometers and sensors are installed in each system. The type and the power range vary according to the control task. The respective requirements and the ambient conditions simultaneously determine which inspections are necessary to check the measuring instruments. Regular calibration is essential to maintain confidence in the measured value or detect any changes in good time. In the latter case the instrument can be readjusted or exchanged before any harm is caused to the process.

Calibrating of measuring instruments

The effort for calibrating measuring instruments is considerable, and many companies are unable – or unwilling – to shoulder it alone. This particularly applies if the process is certified to ISO 9001 or a similar quality assurance system. Quality systems stipulate regular – and traceable – inspections of all measuring instruments. These check measurements are undertaken by calibration laboratories which are certified by the German accreditation body (DAkkS). Many instrument manufacturers, including Wika, have their own facilities for this purpose which are independent of specific products. A wide variety of services may be provided, from verifications of working standards to calibrations of customer-specific designs such as complete multi-point thermometers. The customer's quality management experts can develop differentiated calibration processes for each individual system in cooperation with the laboratory. The following calibration methods are available and they are depending on the requirements.

Comparative calibration

This is the method most commonly employed in calibration laboratories: the device to be calibrated is compared with a higher-quality reference thermometer. The stable test temperature which is necessary for this purpose is usually achieved in immersion baths filled with liquids, salts or powders. Special calibration furnaces are used at higher temperatures. A homogeneous temperature distribution is ensured by interior heating pipes or by solid and highly conductive compensation blocks.

The device to be calibrated is exposed to a constant temperature together with a calibrated instrument as a working reference. As soon as thermal equilibrium has been reached, the values can be read and the measuring characteristics, such as any deviations, determined. This method does not simply enable rapid calibration sequences. It also has economic benefits in that several thermometers can be calibrated at once in the baths or furnaces. Unfortunately, multi-piece test equipment goes hand in hand with a larger measurement uncertainty. Ideally, this will be 10 mK in the Wika laboratory.

Fixed-point calibration

A much smaller measurement uncertainty – as little as ± 2 mK – and hence up to double the instrument precision can be realised using fixed-point calibration. Cells in which fixed points of high-purity substances such as gallium or zinc can be set as the "reference". As a function of temperature and pressure, these substances exist in the three classical physical states. Phase transitions, for example from solid to liquid, can be used for calibration since at constant pressure, the temperature of a substance also remains constant until the phase transition is complete. Apart from the phase transitions, triple points are also employed for some substances. At the

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Comparative calibration in the Wika calibration laboratory

triple point, the three phases of a substance are present in a thermal equilibrium. They can be set very accurately and reproduced at any time. Moreover, they can be maintained over long periods.

The International Temperature Scale defines 16 fixed points, from the triple point of hydrogen (-259.3467 °C) to the freezing point of copper (1084.62 °C). The Wika laboratory, for instance, calibrates at the triple points of mercury and water, at the melting point of gallium and at the freezing points of tin, zinc and aluminium. A temperature range from -33.8344 to 660.323 °C is covered in this way. The sensor platinum of a resistance thermometer, for instance, must satisfy certain purity criteria and the wire winding must be stress-free.

Customer-specific calibrations and conclusion

In some cases, calibration laboratories have to design an inspection procedure on the basis of directives which are explicitly adapted to the device to be calibrated. Temperature sensors with a connected transmitter, which are approved under 2014/32/EU (MID = Measuring Instruments Directive), are a good example here. Their quality must be demonstrated by means of a traceable DAkkS calibration as soon as they have been manufactured. This entails performing a so-called system calibration at three points in the transmitter's measuring range: 0 %, 50 % and 100 %.

A complete multi-point thermometer which is calibrated in a tube furnace with an integrated reference is another example of a customer-specific inspection method. The installed thermocouples are measured along the length of the thermometer lance. A tube furnace containing a block with bores, into which the lance is inserted, is required here. Each of its measuring points is checked at three temperature points (e.g. 200 °C, 400 °C, 600 °C). The length and mass of the tube furnace ensure that the temperature in all bores is identical and remains stable over time.

When it comes to temperature measuring instruments, calibration often involves more than "simply" checking whether the measured value is indicated correctly within the permissible tolerances. It also has a strategic significance in that different methods can be chosen in cooperation with a qualified laboratory. The inspection intervals can be optimised in this way – and the efficiency of the processes improved because higher precision is achievable.

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