

# Process Calibration Tools: Temperature Applications

## Application Note

### Introduction

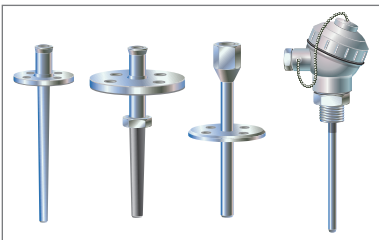
Process Calibration Tools (PCT) is a family of Fluke tools that enable users to calibrate temperature, pressure, flow and electrical sensors, transmitters and gages products in-situ and in I&C and I&E shops.

### Temperature

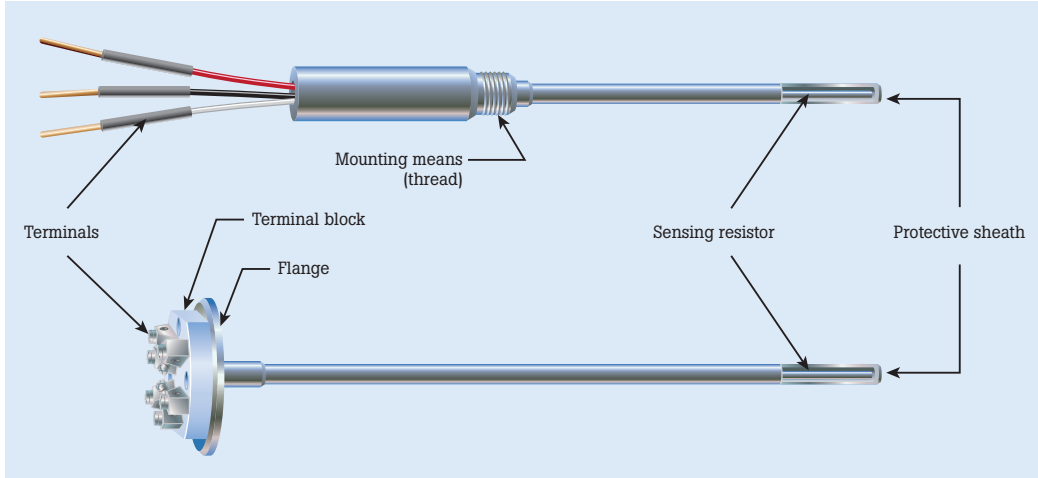
**Electronic thermometers** such as RTDs (resistance temperature detectors), PRTs (platinum resistance thermometers) and thermocouples are often used to monitor temperatures in processes. RTDs and PRTs are used when accuracy is particularly important. Thermocouples are inexpensive and can be used over wider temperature ranges than PRTs and RTDs, but they are less accurate. Failure modes for these sensors include open circuit, short circuit, and drift. Sensor drift is the most common failure mode and is corrected by calibration.

Electronic thermometers include a protective sheath which allows them to be inserted directly into the medium to be measured, or they can be placed in a thermal well. This is used to protect the sensor from vibration and to allow it to be placed in environments under pressure or where it would otherwise not be safe to insert the sheath directly.

**Temperature displays** are digital readouts that convert the changes in electrical resistance



RTDs may be inserted into thermal wells. Some RTDs have large protective sheaths and flanges that make calibration difficult.



The sensing resistor of an RTD is measured at the terminals of the assembly.

of the thermometers into numerical temperature. There are also handheld temperature calibrators that, in addition to displaying temperature, enable the electrical output of electronic thermometers to be calibrated.

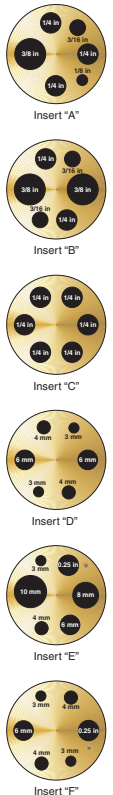
**Temperature sources** are ovens that generate temperatures for calibrating electronic thermometers. There are two types: dry-blocks (also called dry wells) that are typically portable, and baths, which use liquid media to achieve more stable temperatures. Baths are normally larger than dry wells and are not portable.

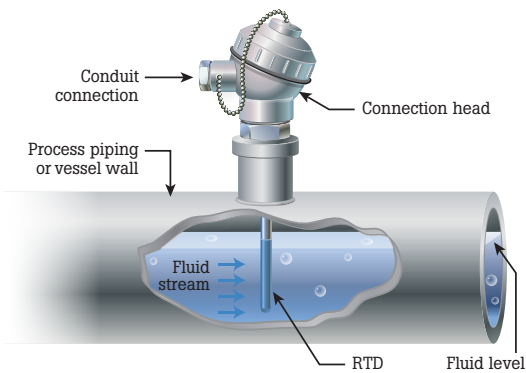
Dry-block calibrators are designed with inserts that contain holes bored into them matching standard diameters used for RTDs, PRTs, and thermocouples. To calibrate an RTD or PRT the probe is removed from the thermal well, or other location where it is mounted, and inserted into the dry-block calibrator. The resistance of the probes is measured at the terminal at pre-determined temperature set-points supplied by the calibrator.

For thermocouples the procedure is the same, except voltage is measured across the terminal rather than resistance.



RTDs are placed in the calibrator in holes bored into interchangeable metal inserts.





RTDs are often inserted in process piping or a vessel wall. Temperature transmitters convert the resistance or voltage supplied by the RTD sensor to a 4-20 milliamp current signal.

**Applications**

**Mechanical thermometers** are often used to measure the temperature in pressurized vessels such as boilers or pipes. They may need to be calibrated for compliance with ISO 9001 or ISO 50001 (energy management), FDA regulation, safety, good manufacturing practices, or to manage energy costs. In some cases, test wells are built into a process so that a reference thermometer can be placed in line with the thermometer to be calibrated in situ.

Mechanical thermometers (bi-metallic, fluid filled, liquid in glass) don't require multifunction calibrators. However, they do require a dry-block or Micro-Bath. Also, if flanges, sockets, or bulbs prevent sufficient immersion in a dry-block calibrator, or if the stem is too short for sufficient immersion in a dry block calibrator, use a Micro-Bath instead. Typically four to six inches and snug contact with the insert is required for sufficient immersion in a dry-block calibrator.

**Sensors and transmitters:** In many installations, a temperature transmitter is connected to the terminal of the RTD, PRT, or thermocouple. The transmitter converts the resistance, or voltage supplied by the sensor, to a 4-20 milliamp signal that can be transmitted to a control panel or PLC. In this case there are



The 914X Dry-Well Calibrators automate heating or cooling the sensor. Process electronics supply loop power, measure resistance, voltage, and 4-20 milliamp signals, and document the results.

two items to be calibrated: the temperature sensor (75 % of the error) and the transmitter.

Calibrating the sensor requires a temperature source such as a dry-block calibrator or Micro-Bath. Calibrating the transmitter requires a Field Metrology Well, multi-function calibrator or documenting process calibrator.

Some temperature transmitters can be adjusted digitally using industry standard digital communication protocols such as HART, Fieldbus, or Profibus. Other temperature transmitters only require a screw driver to adjust a trim pot on face of the transmitter inside the connection head that houses it.

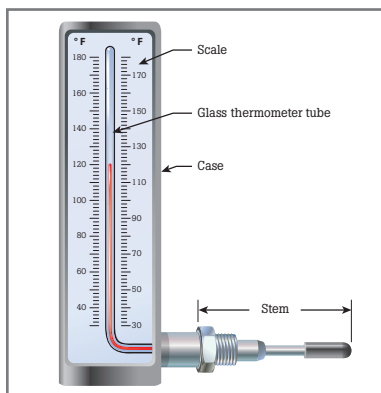
If the sensor or transmitter is found to be out of tolerance, the span and offset have to be adjusted on the transmitter. If the transmitter uses a digital communication protocol the span and offset is adjusted through a digital communicator or with a documenting process calibrator capable of digital communication. Otherwise, trim pots on the transmitter are used to adjust the span and offset.

**Why calibrate?**

The need to achieve consistent results with interchangeable measurement equipment is one of the most important reasons why we calibrate.

Accuracy is an important feature of a calibrator. You may need a particular level of accuracy to comply with standards that specify a test accuracy ratio (TAR) or test uncertainty ratio (TUR). For example many standards require a 4:1 ratio between the specified tolerance of the device under test (DUT), and the accuracy or uncertainty of the calibration equipment.

However, accuracy is also important because when accurate standards are used, downtime typically only needs to be long enough to verify that the instruments are still in tolerance. In contrast, with inaccurate calibration standards more borderline and out-of-tolerance indications are found. As a result, a routine verification turns into an additional adjustment procedure and a final verification at each of the test points to prove the "as left" condition is in tolerance. This more than doubles the down time, and the technician time involved in completing the calibration. This is due to the fact that inaccurate standards tend to not be consistent with each other, requiring more adjustments to correct phantom errors.



Liquid in glass thermometer stem has a bulb.



Fluke documenting process calibrators work together with Fluke dry-block calibrators to automate and document loop calibrations.

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