FLUKE®

Calibration

Comparison calibration made easy with a 914X Series Field Metrology Well

Application Note

When is a dry-well also a precision thermometer readout? The answer is when it is a Fluke Calibration 914X Series Field Metrology Well with the process option installed.

With excellent stability, uniformity, and plenty of well depth, Fluke Calibration 914X Series Field Metrology Wells supply low uncertainties for calibrating platinum resistance thermometers (PRTs), thermocouples, and other industrial thermometers. The 9142 and 9143 models offer ± 0.2 °C display accuracy over their full range, and the 9143 model offers ± 0.5 °C display accuracy up to 660 °C. Using an industry standard TUR of 4:1, this allows you to provide certification of ± 0.8 °C on the 9142 and 9143 or ± 2.0 °C on the 9143.

With the process version of any Field Metrology Well model, you can fully automate calibrations of PRTs, thermocouples, and other industrial thermometers. Also included in the process version is the ability to perform comparison calibrations against a reference PRT, using the built-in readout input that has accuracy of ± 0.01 °C to ± 0.07 °C. This can increase your ability to provide certifications often less than ± 0.25 °C or about a four times improvement over using the display alone.

Using a built-in reference thermometer improves the accuracy of the calibration, reduces the amount of extra equipment that needs to be carried—and, with the smart connector technology, it's easy to plug and measure with precision. You can also use the reference sensor for more accuracy when calibrating shorter sensors that cannot reach the calibration zone of the insert.

The built-in two-channel input process option: reference input combined with UUT input

There is a jack for a plug-and-play calibrated reference sensor to improve accuracy. With it, you can perform comparison calibrations against a reference PRT using the built-in readout. The built-in reference input will accept a 4-wire PRT as the reference thermometer. The input channel for the unit under test (UUT) connects to a 4-, 3-, or 2-wire PRT or RTD, a thermocouple, or a 4-20 mA signal (including loop power supply).

1. PRT Reference Thermometer 6-pin DIN smart connector
2. 4–20 mA connector allows current and/or voltage probes to be connected for measurement and includes a 24 V loop power supply when needed to power common transmitters
3. PRT/RTD connector for 4-,3-, and 2- wire measurement
4. Thermocouple connector (subminiature)
5. Fuse for the 4–20 mA circuit

The –P (process version) panel is the readout portion of the instrument and is only available with –P models.

Reference PRTs for Fluke Calibration 914X Series Field Metrology Wells contain individual calibration constants that reside in a memory chip located inside the sensor housing, so sensors may be used interchangeably. The ability to utilize calibration constants allows the full calibration accuracy of the probe to be used automatically. This dramatically improves probe performance. The chip is contained in a 6-pin DIN smart connector. A standard 5-pin DIN will also work, but then the calibration information has to be entered in manually.

The reference PRT probe must be ordered separately with a smart connector on it. The smart connector is our Fluke Calibration type "A" termination (Info-Con). So a 5626-12 probe would be ordered as a 5626-12-A. If the PRT comes with the smart 6-pin DIN connector, then the calibration information is contained in the probe. The smart connector allows the reference temperature to accurately be displayed from a probe inserted into the dry-well by simply plugging the reference probe connector into the readout portion of the instrument panel.

If the probe is recalibrated, the new coefficients from the calibration report will probably need to be re-programmed into the reference PRT. This can be done from the front panel of the 914X.

How to use the reference probe

Once the reference probe is plugged into the instrument panel of a process version ("–P") Fluke 914X Field Metrology Well the display temperature of the instrument will match the temperature sensed by the reference probe.

Place the reference probe at the bottom of the calibrated zone of the dry-well. Insert the probe(s) to be calibrated into the dry-well with the reference probe. Be sure there is a snug fit between all inserts and sensors. Air gaps will lead to errors.

If the sensors being calibrating are too short to reach the bottom of the insert, then insert the reference sensor to the same level as the probes to be calibrated. Caution: if the sensors to be calibrated have a very shallow insertion length, then it may be necessary to calibrate them in a liquid bath for the reference probe and units under test to have sufficient immersion for an accurate calibration.

Using this technique, the accuracy of the measurement will depend on:

1. Axial Uniformity (9142-P: ±0.05 °C)
2. Radial Uniformity (9142-P: ±0.01 °C)
3. Loading Effect (9142-P: ±0.006 °C
4. Stability (9142-P: ±0.01 °C)
5. Reference probe calibrated accuracy (5616-12-A: ±0.011 °C)
6. Thermometer readout accuracy (9142-P: ±0.010 °C to ±0.025 °C)

Total accuracy in this example: ±0.06°C using reference thermometer compared to the 9142-P only using the display accuracy of ±0.2 °C.

For very short sensors, the error due to stem effect should be considered. For more information about calculating dry-well uncertainties see the Fluke Calibration application note "Understanding the uncertainties associated with the use of Metrology Wells."

How to program the smart connector

Step 1.
Plug the reference sensor into the instrument panel of the Fluke Calibration 914X Series Field Metrology Well.

Step 2. From the main menu, press F3 (Reference Input). The REF INPUT (REFERENCE INPUT) menu contains the parameters for the reference input to the readout module of the instrument. The Reference Input is only compatible with PRTs with ITS-90, Callendar Van-Dusen, or IEC-751 coefficients. Additionally, the Reference Input will read straight resistance.

Step 3. Press F1 (Program Probe).
The PROG PROBE (REFERENCE PROBE SETUP) menu is used to set up the reference probe parameters.

Step 4. Enter the serial number of the probe.
The SERIAL (SERIAL NUMBER) parameter allows the user to enter ten digit alpha numeric serial number for the reference probe. Character range = {0-9, A-Z, '-', <Blank>}. Minimum required is one character.

When a blank space is entered, any characters after the blank are dropped. For example, change S/N 1234-5678 to S/N TEST1. Enter TEST1<Blank Space>678. The serial number will drop the last three characters and enter the S/N TEST1.

Step 5. Enter the calibration date.
The CAL DATE parameter is used to enter the calibration date for the reference probe. Use the arrow keys to enter the calibration date in the format selected in DATE FORMAT.

Step 6. Enter the Probe type (ITS-90, CVD, etc.)
The PROBE TYPE parameter is used to choose which probe conversion type to be setup. Use the left and right arrow keys to select the conversion type and press "Enter" to accept selection.

Step 7. Enter the probe coefficients.
The TYPE parameter can be ITS-90, Callendar-Van Dusen (CVD), IEC-751, or Resistance. The ITS-90 option is for PRTs calibrated and characterized using the International Temperature Scale of 1990 (ITS-90) equations. Subranges 4, and 7 through 11 are supported. Subrange 5 coefficients can be used in subrange 4 with negligible additional uncertainty.

Table 1. Subranges of the ITS-90

Sub range coefficients	Temperature range
a4, b4	–200 °C to 0 °C
a5, b5	–40 °C to 30 °C
a7, b7, c7	0 °C to 660 °C
a8, b8	0 °C to 420 °C
a9, b9	0 °C to 232 °C
a10, b10	0 °C to 157 °C
a11, b11	0 °C to 30 °C

The parameters that appear when ITS-90 is selected are "Serial" (Serial Number), "Cal Date", "RTPW", "COEF A", "COEF B", "COEF C", "COEF A4", and "COEF B4". These should be set with the corresponding values that appear on the calibration certificate of the PRT. The parameter "RTPW" takes the triple point of water resistance, often labeled "RO" or "R(273.16K)" on the certificate. Parameters "COEF A", "COEF B", "COEF C" take the an, bn and cn coefficients where n is a number from 7 to 11. Parameters "COEF A4" and "COEF B4" take the a4 and b4 coefficients on the certificate. Any ITS-90 parameter of the instrument that does not have a corresponding coefficient on the PRT's certificate must be set to 0.

Table 2 shows which parameter to set for each of the coefficients that may appear on the certificate. The example that follows demonstrates how to set the ITS-90 parameters for certain cases.

Table 2. Parameters to set for coefficients appearing on the certificate

914X ITS-90 coefficient	Certificate value
COEF A	a7, a8, a9, a10, or a11
COEF B	b7, b8, b9, or 0
COEF C	c7 or 0
COEF A4	a4
COEF B4	b4

Example
A PRT was calibrated to ITS-90 and its calibration certificate states values for coefficients Rtpw, a4, b4, a8, and b8. Set the instrument's parameters with values from the certificate as follows.

Table 3. Setting Coefficients Rtpw, a8, b8, and b4

914X coefficient	Certificate value
RTPW	Rtpw
COEF A	a8
COEF B	b8
COEF C	0

Callendar-Van Dusen
For RTD probes that use the CVD (Callendar-Van Dusen) equation, please refer to the 914X Field Metrology Well Technical Guide.

Step 8. Program the probe.
The PROG PROBE parameter is used to tell the instrument to program a smart connector (e.g. Fluke Calibration type "A" probe termination, Info-Con) with the appropriate probe coefficients. Use the arrow keys to select "Yes" or "No". If "Yes" is selected, the smart connector will be programmed with the appropriate coefficients for the selected conversion type. For ITS-90 and CVD, the coefficient values need to entered before programming the smart connector. For IEC751 and resistance, no values are required to program the smart connector.

Step 9. Test the coefficients.
To ensure the coefficients are entered correctly, test the calculation against the table values in the calibration report. The TEST CALC (TEST REFerance CALCULATION) allows the technician to test the output of a specific conversion algorithm. Simply select the conversion type and enter a value for the requested parameter. Press ENTER; the algorithm computes the answer, and it is displayed immediately in the parentheses at the bottom of the screen, TEMPERATURE: XX.XXX.

Applications

1. If you have been bringing an external readout to improve the accuracy of your dry-well calibrations, you will have one less instrument to carry in the future, since a very accurate readout is built-in. You can still achieve the accuracy you attained using the external readout.

2. If you need to calibrate sensors used for critical measurements and you have not been using a reference thermometer, then you may not have the accuracy you need to ensure your sensors remain in tolerance. Remember, calibration systems are commonly required to deliver performance that is four times the performance of the probe being calibrated, which can be challenging if you use only the display of a typical dry-well calibrator.

Symptoms of this problem include:

- Frequent adjustments required after the As Found condition is taken.

- Interchangeability of calibration instruments appears to be an issue.
- Greater than desired downtime troubleshooting non-conforming processes

3. If you calibrate short sensors in dry-wells, you may have an accuracy problem, since the probes do not reach the calibrated zone of the dry-well. You can solve this problem by using a calibrated reference thermometer in the same vertical zone where the sensors are placed. You will have some additional uncertainty due to stem effect especially if the units under test are very different in construction from the reference probe.

Conclusion

Using a reference probe with a Fluke Calibration 914X Series Field Metrology Well is as easy as plug-and-play. It will significantly improve your capability to calibrate high-accuracy probes used in critical processes. This extra capability will allow you offer more high quality services to your customers with less equipment than was required before.