FLUKE®
Calibration

Industrial temperature readout and probe selection guide

1502A

1504

1523 1524

1529


1586A

Industrial temperature sensors are typically calibrated by placing them in a stable temperature source (dry-well, furnace, calibration bath) and comparing their output to a reference standard probe connected to a thermometer readout. This document provides a guide for selecting a thermometer readout and companion reference standard probe that will provide adequate system accuracy required to calibrate common temperature sensors such as PRTs and thermocouples.

This guide covers the most common applications of precision thermometers in calibration such as choosing a thermometer to improve calibration accuracy in a bath or dry-well or to compare against process instrumentation in-situ (e.g. a thermowell next to a gauge or transmitter). Please consult a Fluke Calibration temperature specialist to assist with your equipment selection if you have a special application such as measuring surface temperatures, liquids with high pH, air temperature, or temperature inside an enclosure such as a freezer or oven.

Five steps in choosing a thermometer readout and reference probe:

step 1 Choose the best thermometer readout for the industrial sensor application.

step 2 Select the reference probe considering the temperature range of the sensor application and immersion depth required.

step 3 Determine the combined system accuracy of the readout and reference probe selected.

step 4 Verify that the readout and probe system selected will provide the accuracy needed to calibrate the sensor under test.

step 5 Evaluate if additional calibration is required.

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Step 1. Choose the best thermometer readout for the industrial application.

Several questions should be considered in selecting the right thermometer readout:

- Which temperature sensors need to be calibrated—PRTs/RTDs, thermistors, thermocouples?
- Will the readout be used in the field or in a calibration lab?
- How many channels are needed on the readout?
- What level of data logging, graphing and recording features are required?
- Is temperature source control of dry-wells, baths, or furnaces desired to help automate sensor calibration?

The following table provides a guide for selecting a readout with these technical needs in mind.

						
Technical needs	**1523**	**1524**	**1502A**	**1504**	**1529**	**1586A**
Measure PRTs / RTDs	•	•	•		•	•
Measure thermistors	•	•		•	•	•
Measure thermocouples	•	•			•	•
Battery powered	•	•	Optional	Optional	Optional	
Handheld design	•	•				
Single channel	•		•	•		
Multi channel (maximum channels)		2			4	40
Record data (maximum readings)	25	15,000			8,000	75,000
Automated data logging		•			•	•
Graphing (maximum channels)	1	2				4 (in color)
Statistical functions (min, max, avg, etc)	•	•			•	•
Temperature source control (Fluke Calibration dry-wells, baths, furnaces)						•

Table 1. Fluke Calibration thermometer readouts.

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Step 2. Select the reference probe considering the temperature range of the sensor application and immersion depth required.

It is important to select a reference probe that covers the full temperature range of the sensor application. Table 2 summarizes temperature ranges for selected reference probes.

Model		Probe Range	Transition Junction Range	Size	Basic Accuracy[4]	Minimum Immersion Depth
Secondary Reference PRT[1]						
	5615-6	–200 °C to 200 °C	–50 °C to 200 °C	152 mm x 4.76 mm (6.0 in x 0.188 in)	± 0.013 °C at 0.010 °C	100 mm (4.0 in)
	5615-9	–200 °C to 420 °C	–50 °C to 200 °C	229 mm x 4.76 mm (9.0 in x 0.188 in)	± 0.013 °C at 0.010 °C	100 mm (4.0 in)
	5615-12	–200 °C to 420 °C	–50 °C to 200 °C	305 mm x 6.35 mm (12.0 in x 0.250 in)	± 0.013 °C at 0.010 °C	127 mm (5.0 in)
Precision Industrial PRT[1]						
	5627A-6	–200 °C to 300 °C	0 °C to 150 °C	152 mm x 4.7 mm (6.0 in x 0.187 in)	± 0.05 °C at 0 °C	100 mm (4.0 in)
	5627A-9	–200 °C to 300 °C	0 °C to 150 °C	229 mm x 4.7 mm (9.0 in x 0.187 in)	± 0.05 °C at 0 °C	100 mm (4.0 in)
	5627A-12	–200 °C to 420 °C	0 °C to 150 °C	305 mm x 6.35 mm (12.0 in x 0.250 in)	± 0.05 °C at 0 °C	127 mm (5.0 in)
Secondary Standard PRT[1]						
	5628	–200 °C to 661 °C	0 °C to 80 °C	305 or 381 mm x 6.35 mm (12.0 or 15.0 in x 0.250 in)	± 0.006 °C at 0 °C	127 mm (5.0 in)
Full Immersion PRT[2]						
	5606	–200 °C to 160 °C	–200 °C to 160 °C	50 mm x 3.1 mm (2.0 in x 0.125 in)	± 0.05 °C	76 mm (3.0 in)
Thermistor Secondary Probe[3]						
	5610	0 °C to 100 °C	0 °C to 100 °C	152 or 229 mm x 3.2 mm (6.0 or 9.0 in x 0.125 in)	± 0.01 °C	76 mm (3.0 in)

[1]17025 accredited calibration included.
[2]No calibration included. Check with your distributor for calibration options.
[3]NIST traceable calibration included. NVLAP accredited calibration optional.
[4]"Basic Accuracy" includes calibration uncertainty and short-term repeatability. It does not include long-term drift.

Table 2: Temperature ranges for select Fluke Calibration probes.

Consider the length

Make sure the reference probe is long enough to reach the bottom of the dry-well or the sensing element of the unit under test in a bath. The sensing element of a PRT is usually in the bottom one inch of the probe. A thermistor sensing element is only a few millimeters at the bottom of the probe. The measurement junction of a thermocouple is where the two dissimilar wires connect.

To ensure the reference and the unit under test are at the same temperature during comparison calibration, the sensing element of the unit under test needs to be vertically aligned with the center of the sensing element of the reference probe. Also, inaccurate measurements can occur if either the reference probe or the unit under test is not sufficiently immersed in the dry-well or bath.

Consider the diameter

Minimum immersion is the minimum depth the probe needs to be inserted into the bath or dry-well for accurate measurement. It is determined by the diameter of the selected probe and the length of its internal sensing element. A general rule is the minimum probe immersion needs to be 15 times the probe diameter plus the sensor length. Fluke Calibration 6-inch and 9-inch PRTs have a 3/16 inch diameter rather than a 1/4 inch diameter and can be a better choice for calibrating shorter probes. See Table 2 for minimum immersion depths for select probes.

Safety and other considerations

Some applications may require exposing more of the probe to extreme temperatures than is desirable. Exposing the probe handle to extreme temperatures poses safety concerns for the user, since it may be too hot or cold to touch without safety gear. Also, the transition junction is located inside the probe handle base where the probe connects to the cable and can be damaged by extreme temperatures. Finally, if high temperatures in the transition junction cause the insulation resistance to decrease below 100 MΩ, the performance of the probe might also decrease.

For example, a 5615-12 Secondary Reference PRT can operate over a range from –200 °C to 420 °C. However, the 5615-12 transition junction range is –50 °C to 200 °C. This means the probe is designed to measure temperatures from –200 °C to 420 °C, but the probe will be damaged if the handle is exposed to temperatures outside the range of –50 °C to 200 °C. Even if the probe is not damaged, touching a probe handle that is extremely hot or cold with bare hands could result in burns.

In this example, the 5615-12 can be used to calibrate sensors as low as -200 °C, but would be damaged if placed in a freezer at -80 °C since the transition junction lower limit is -50 °C. For a freezer application, the 5606 Full Immersion PRT would be the right choice since the probe and transition junction can operate at a lower limit of -200 °C.

Step 3. Determine the combined system accuracy of the readout and reference probe selected.

Table 3 shows the system accuracy for Fluke Calibration 1523/1524, 1502A/1504, 1529, and 1586A Super-DAQ thermometer readouts and selected reference probes (5615, 5627A, 5628, 5605, 5610) or Type T and K thermocouples. For example, the 1586A Super-DAQ with DAQ-STAQ Multiplexer and a 5628 Secondary Standard PRT has a system accuracy of ± 0.011 °C at 0 °C.

Reference probes are connected to the thermometer readout, but readouts don't all share the same connection scheme. When a readout and probe are paired, be sure to choose a model terminated with the right connector. For your convenience, probe models with the correct termination for the readout are shown in Table 3. Note that the readout accuracy with a 5606 probe assumes that the probe has received an optional calibration.

1523/1524 accuracy with selected probes (± °C)							
	Secondary Reference PRT	Precision Industrial PRT	Secondary Standard PRT	Full Immersion PRT	Thermistor Probe	Type T Thermocouple	Type K Thermocouple
Connector type: P 	5615-6-P 5615-9-P 5615-12-P	5627A-6-P 5627A-9-P 5627A-12-P	5628-12-P	5606-50-P	5610-9-P		
Temperature (°C)							
-200	0.025	0.027	0.024	0.031	n/a	0.856	0.885
0	0.021	0.051	0.035	0.049	0.012	0.339	0.333
100	0.029	0.067	0.041	0.067	0.028	0.285	0.322
300	0.044	0.107	0.054	n/a	n/a	0.239	0.332
420	0.054	0.135	0.062	n/a	n/a	n/a	0.330
660	n/a	n/a	0.080	n/a	n/a	n/a	0.344
1300	n/a	n/a	n/a	n/a	n/a	n/a	0.451

The P type connector is a smart Lemo connector. It contains a microchip with the probe calibration coefficients for easy plug-and-play measurement.
A Lemo-to-Unversal Thermocouple adapter 2373-LTC is available for connection to thermocouples.
The 1524 can measure two channels at a time, but only one channel can be a thermocouple.
5615-6 range is -200 °C to 300 °C. 5615-9, -12 range is -200 °C to 420 °C. 5627A-6, -9 range is -200 °C to 300 °. 5627A-12 range is -200 °C to 420 °.

1502A/1504 accuracy with selected probes (± °C)					
	1502 model				1504 model
	Secondary Reference PRT	Precision Industrial PRT	Secondary Standard PRT	Full Immersion PRT	Thermistor Probe
Connector type: D 	5615-6-D 5615-9-D 5615-12-D	5627A-6-D 5627A-9-D 5627A-12-D	5628-12-D	5606-50-P	5610-9-D
Temperature (°C)					
-200	0.024	0.026	0.008	0.031	n/a
0	0.014	0.049	0.009	0.047	0.012
100	0.020	0.064	0.013	0.064	0.025
300	0.033	0.103	0.021	n/a	n/a
420	0.042	0.131	0.026	n/a	n/a
660	n/a	n/a	0.038	n/a	n/a

The 1502A works with probes that are terminated with type D connector.
This is a standard DIN connector and does not contain a microchip with the probe coefficients.
5615-6 range is -200 °C to 300 °C. 5615-9, -12 range is -200 °C to 420 °C. 5627A-6, -9 range is -200 °C to 300 °C. 5627A-12 range is -200 °C to 420 °C.

	1529 accuracy with selected probes (± °C) – two thermocouple and two PRT/thermistor inputs						
	Secondary Reference PRT	Precision Industrial PRT	Secondary Standard PRT	Full Immersion PRT	Thermistor Probe	Type T Thermocouple	Type K Thermocouple
Connector type: L 	5615-6-L 5615-9-L 5615-12-L	5627A-6-L 5627A-9-L 5627A-12-L	5628-12-L	5606-50-P	5610-9-L		
Temperature (°C)							
-200	0.024	0.026	0.008	0.031	n/a	1.000	1.000
0	0.014	0.049	0.009	0.047	0.012	0.400	0.400
100	0.020	0.064	0.013	0.064	0.025	0.300	0.400
300	0.033	0.103	0.021	n/a	n/a	0.300	0.400
420	0.042	0.131	0.026	n/a	n/a	n/a	0.400
660	n/a	n/a	0.038	n/a	n/a	n/a	0.400
1300	n/a	n/a	n/a	n/a	n/a	n/a	0.400

The 1529 works with probes that are terminated with the type L connector. These are gold plated mini spade lugs. The 1529 is also compatible with gold pins, mini banana plugs, and bare wire probe terminations. This version of the 1529 is also compatible with mini thermocouple connectors.
5616-6 range is -200 °C to 300 °C. 5615-9, -12 range is -200 °C to 420 °C. 5627A-6, -9 range is -200 °C to 300 °C. 5627A-12 range is -200 °C to 420 °C.

	1529-R accuracy with selected probes (± °C) – four PRT/thermistor inputs				
	Secondary Reference PRT	Precision Industrial PRT	Secondary Standard PRT	Full Immersion PRT	Thermistor Probe
Connector type: L 	5615-6-L 5615-9-L 5615-12-L	5627A-6-L 5627A-9-L 5627A-12-L	5628-12-L	5606-50-P	5610-9-L
Temperature (°C)					
-200	0.024	0.026	0.008	0.031	n/a
0	0.014	0.049	0.009	0.047	0.012
100	0.020	0.064	0.013	0.064	0.025
300	0.033	0.103	0.021	n/a	n/a
420	0.042	0.131	0.026	n/a	n/a
660	n/a	n/a	0.038	n/a	n/a

The 1529 works with probes that are terminated with the type L connector. These are gold plated mini spade lugs.
The 1529 is also compatible with gold pins, mini banana plugs, and bare wire probe terminations.
5615-6 range is -200 °C to 300 °C. 5615-9, -12 range is -200 °C to 420 °C. 5627A-6, -9 range is -200 °C to 300 °C.
5627A-12 range is -200 °C to 420 °C.

1529-T accuracy with selected probes (± °C) – four thermocouple inputs		
	Type T Thermocouple	Type K Thermocouple
Temperature (°C)		
-200	1.000	1.000
0	0.400	0.400
100	0.300	0.400
300	0.300	0.400
420	n/a	0.400
660	n/a	0.400
1300	n/a	0.400

This version of the 1529 is compatible with mini thermocouple connectors.

1586A and DAQ-STAQ Multiplexer Accuracy with Selected Probes (± °C)							
	Secondary Reference PRT	Precision Industrial PRT	Secondary Standard PRT	Full Immersion PRT	Thermistor Probe	Type T Thermocouple	Type K Thermocouple
Connector type: L 	5615-6-L 5615-9-L 5615-12-L	5627A-6-L 5627A-9-L 5627A-12-L	5628-12-L	5606-50-P	5610-9-L		
Temperature (°C)							
-200	0.024	0.026	0.010	0.031	n/a	0.760	0.780
0	0.014	0.048	0.011	0.046	0.012	0.300	0.300
100	0.019	0.064	0.012	0.063	0.016	0.250	0.290
300	0.032	0.103	0.018	n/a	n/a	0.210	0.290
420	0.040	0.130	0.023	n/a	n/a	n/a	0.290
660	n/a	n/a	0.033	n/a	n/a	n/a	0.290
1300	n/a	n/a	n/a	n/a	n/a	n/a	0.370

The 1586A works with probes that are terminated with the type L connector. These are gold plated mini spade lugs.
The 1586A is also compatible with gold pins, mini banana plugs, bare wire, and mini thermocouple probe terminations.
5615-6 range is -200 °C to 300 °C. 5615-9, -12 range is -200 °C to 420 °C. 5627A-6, -9 range is -200 °C to 300 °C. 5627A-12 range is -200 °C to 420 °C.

Table 3: Readout accuracy with selected probes.

Step 4. Verify the readout and probe system selected will provide the accuracy needed to calibrate the sensor under test.

The calibration system comprised of a readout and reference probe needs to have a higher level of accuracy than the temperature sensor being calibrated. A "test accuracy ratio" (TAR) of 4:1 or 3:1 is commonly used as a guide-line. A 4:1 TAR means the calibration system is four times more accurate than the sensor being calibrated. In this example, the system with a 4:1 TAR would be more accurate than a system with 3:1 TAR.

Table 4 shows the minimum system accuracy required to calibrate common temperature sensors (Grade A and B PRTs, Type T and K thermocouples). For example, a readout and reference probe system with a combined accuracy of ± 0.06 °C would be needed to calibrate a Grade B PRT at 0 °C with a 4:1 TAR.

Assume the 1586A Super-DAQ with DAQ-STAQ Multiplexer and a 5628 Secondary Standard PRT were selected as the readout-and-probe system. The 1586A/5626 system would be a good choice to calibrate a Grade B PRT. The 1586A/5626 system accuracy of ± 0.011 °C at 0 °C is much better than the ± 0.06 °C system accuracy at 0 °C required to calibrate a Grade B PRT with a 4:1 TAR.

Temperature (°C)	Grade A PRT*	Grade B PRT*	Type T Special	Type T Standard	Type K Special	Type K Standard
4:1 Test Accuracy Ratio						
-200	0.12	0.27	n/a	0.25	n/a	0.55
0	0.03	0.06	0.13	0.25	0.28	0.55
100	0.08	0.17	0.13	0.25	0.28	0.55
300	0.16	0.38	0.30	0.56	0.30	0.56
370	0.19	0.45	0.37	0.69	0.37	0.69
420	0.21	0.50	n/a	n/a	0.42	0.79
660	0.31	0.76	n/a	n/a	0.66	1.24
1260	n/a	n/a	n/a	n/a	1.26	2.36
3:1 Test Accuracy Ratio						
-200	0.16	0.36	n/a	0.33	n/a	0.73
0	0.04	0.08	0.17	0.33	0.37	0.73
100	0.10	0.22	0.17	0.33	0.37	0.73
300	0.21	0.50	0.40	0.75	0.40	0.75
370	0.25	0.60	0.49	0.93	0.49	0.93
420	0.28	0.67	n/a	n/a	0.56	1.05
660	0.42	1.01	n/a	n/a	0.88	1.65
1260	n/a	n/a	n/a	n/a	1.68	3.15

*ASTM Specification E1137 "Standards Specification for Industrial Platinum Resistance Thermometers"

Table 4: Minimum system accuracy required for PRT and thermocouple calibration (± °C).

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Step 5. Evaluate if additional calibration is required.

Factory calibration

It is standard practice for all Fluke instruments to include a factory calibration that is traceable to national standards. Traceability means that there is an unbroken chain of comparisons between the instrument and a national standard providing assurance that measurements obtained with the instrument correlate to a national standard at a particular level of uncertainty.

In a few cases, probes such as the 5606 do not include a factory calibration, but a calibration is an available option. If you purchase an uncalibrated probe, then the chain of traceability is broken until a calibration is performed.

With many Fluke instruments, the factory calibration is also accredited to ISO 17025. Table 5 summarizes the factory calibrations for the instruments discussed in this guide. Typically, type T and type K thermocouples are provided uncalibrated by the manufacturer. Check with your distributor about temperature instrument calibration options available.

Model	Factory Calibration	
	Accredited	Traceable
5615	Standard	Standard
5627A	Standard	Standard
5626	Standard	Standard
5610	Optional	Standard
5606	Optional	Optional
1523	Optional	Standard
1524	Optional	Standard
1502A	Standard	Standard
1504A	Standard	Standard
1529	Standard	Standard
1586A	Optional	Standard

Table 5: Factory calibration included with selected Fluke readouts and probes.

System calibration

In addition to a factory calibration for both the probe and readout, you may desire to verify the performance of the probe and readout together with a "system calibration." This system calibration provides a higher level of assurance that the instruments are performing as expected when combined together and all probe coefficients are entered correctly into the readout. Check with your distributor about system calibration options available.

Summary

This guide has covered the steps to follow when choosing a readout and probe appropriate for your application. Temperature range of the application and accuracy required are key considerations, but other factors discussed in this guide should be evaluated. If you have a special application such as measuring surface temperatures, liquids with high pH, air temperature, or temperature inside an enclosure such as a freezer or oven, please consult a Fluke Calibration temperature specialist to assist with your equipment selection.

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