Thermistor Standards Probes

- Accuracy to ±0.001 °C
- Affordable system accuracy to ±0.004 °C or better
- NIST-traceable calibration included from manufacturer; accredited Hart calibration optional

If you want a high-accuracy probe with excellent stability at a great price, the Model 5640-series Thermistor Standards Probes give you all three in a great package. Why pay for an SPRT when you can get ±0.001 °C accuracy from 0 °C to 60 °C in a calibrated thermistor probe for about one-third the cost of an uncalibrated SPRT alone?

Each probe uses an ultra-stable glass thermistor enclosed in a thin-wall stainless steel tube. The basic semiconductor element is a bead of manganese, nickel, and cobalt oxides mounted on 0.1 mm platinum wires. For long-term stability, the thermistor is aged at various temperatures for 16 weeks. During the aging process, verification of the probe's stability is done to ensure performance to published specs.

The 5640, 5641, and 5642 thermistor probes are designed for the temperature range of 0 °C to 60 °C. The 5643 and 5644 probes span the 0 °C to 100 °C temperature range. They offer stability of either ±0.002 °C or ±0.005 °C. These stability levels are guaranteed for one full year.

Precision calibration, traceable to NIST, is provided with each probe. A computer-generated table in increments of 0.01 °C is furnished with each calibration based on the formula:

$$R = \exp\left(A + \frac{B}{T} + \frac{C}{T^2} + \frac{D}{T^3}\right)$$

The constants for the formula are obtained from a polynomial regression performed on the calibration data obtained. Over the range of 0 °C to 60 °C, calibration is performed at the triple point of water (0.01 °C) and 15 °C, 25 °C, 30 °C, 37 °C, 50 °C and 60 °C. For the 0 °C to 100 °C temperature range, the additional calibration points of 80 °C and 100 °C are used.

Each probe is individually calibrated and includes a report of calibration from the manufacturer. Contact Hart for calibration in Hart's NVLAP accredited lab.

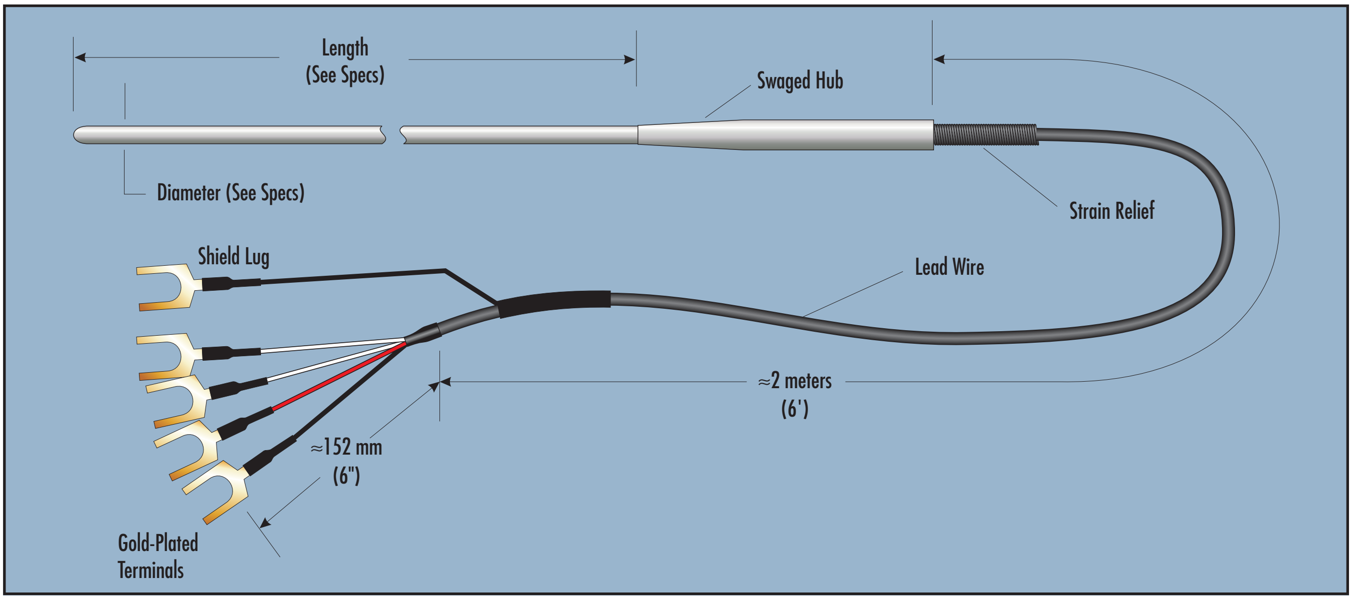
Thermistor standards are rugged, precision sensors suitable for use as secondary or working temperature standards for laboratory metrology applications. Because they generally are not affected by shock and vibration, you can use them in the most difficult field environments without worrying about calibration integrity.

Combine these probes with Hart's 1560 *Black Stack* thermometer to read directly in °C, °F, or K. This combination gives you resolution of 0.0001 degrees and total system accuracy is better than ±0.004 °C.

Compare the cost of a 5640 calibrated probe and a *Black Stack* thermometer to the cost of one uncalibrated SPRT. Between 0 °C and 100 °C, nothing beats the value of the 5640 Series Thermistors.

Thermistor Standards Probes

FLUKE®
Hart Scientific®



Specifications

Model	Diameter x Length	Range	Drift °C/Year	Accuracy (Mfr.)† 0–60 °C	60–100 °C	Wires	Nominal Resistance at 25 °C
5640	6.35 x 229 mm (0.25 x 9 in)	0 °C–60 °C	±0.005 °C	±0.0015 °C	n/a	4	4.4 kΩ
5641	3.18 x 114 mm (0.125 x 4.5 in)	0 °C–60 °C	±0.002 °C	±0.001 °C	n/a	4	5 kΩ
5642	3.18 x 229 mm (0.125 x 9 in)	0 °C–60 °C	±0.002 °C	±0.001 °C	n/a	4	4 kΩ
5643	3.18 x 114 mm (0.125 x 4.5 in)	0 °C–100 °C	±0.005 °C	±0.0015 °C	±0.0025 °C	4	10 kΩ
5644	3.18 x 229 mm (0.125 x 9 in)	0 °C–100 °C	±0.005 °C	±0.0015 °C	±0.0025 °C	4	10 kΩ

†Does not include long-term drift.

Ordering Information

5640-X	Standards Thermistor Probe
5641-X	Standards Thermistor Probe
5642-X	Standards Thermistor Probe
5643-X	Standards Thermistor Probe
5644-X	Standards Thermistor Probe

X = termination. Specify "B" (bare wire), "D" (5-pin DIN for Tweener Thermometers), "G" (gold pins), "I" (INFO-CON for 1521 or 1522 Handheld Thermometers), "J" (banana plugs), "L" (mini spade lugs), "M" (mini banana plugs), or "S" (spade lugs).

Thermistors make great reference thermometers!

Contrary to some traditional belief, reference-grade thermistors do indeed make great temperature standards. Consider:

- Stability. Today's glass-encapsulated thermistors are well sealed to prevent sensor oxidation and drift. In fact, standards-level thermistors usually won't drift more than a few millidegrees in a year.
- Accuracy. Thermistors are easier (than PRTs) to read accurately because of their larger base resistance and large change in resistance-per-degree. It's common to get meaningful and repeatable readings from a thermistor with resolution of 0.0001 °C.
- Durability. While a bare thermistor bead can be fairly delicate, a properly constructed stainless steel-sheathed thermistor probe can be more rugged than a PRT or SPRT.

For about the same cost of a secondary level PRT, you can buy a well-calibrated standards thermistor probe with accuracy and stability that rivals an SPRT. You can also save wear and tear on your SPRT by using a thermistor over the 0 °C to 100 °C temperature range.

See the article *Thermistors: the under appreciated temperature standards* on page 76 for a more detailed examination on this subject.

Secondary Reference Thermistor Probes

- Short-term accuracy to ± 0.01 °C; one-year drift < ± 0.01 °C
- Accredited NVLAP calibration optional
- Flexible Teflon and silicone coated fast-response models
- Rugged polished stainless steel sheaths

Hundreds of thousands of thermistors are sold every year, but only a few have the stability necessary for use as high-accuracy thermometry standards. If you're looking for economical lab-grade thermistor probes for accurate work across a narrow temperature range, Hart's Secondary Reference Series thermistor probes are the best you can buy.

These thermistors are available in a variety of sheath materials appropriate for your specific application. In addition to our metal-sheathed probes, we offer flexible Teflon encapsulated and silicone coated thermistors that have smaller tips and can measure those places where even a metal-sheathed thermistor can't reach.

Teflon encapsulated thermistor

The 5611T is an especially versatile Teflon coated thermistor probe. With a Teflon encapsulated tip that is just 3 mm (0.12 in) in diameter and a Teflon coating that makes it impervious to most liquids, the Teflon Probe is handy for measuring in a wide variety of applications, including bio-pharmaceuticals. It's even immersible to nearly 20 feet and flexible enough that you could roll it up into a ball in your hand if you wanted to!

The 5611T's thermistor bead is encapsulated in a Mylar sleeve that is encapsulated inside a Teflon sleeve. The Teflon sleeve is then melted around the Teflon-insulated cable, forming a moisture-proof seal.

Stainless steel sheathed thermistors

Our stainless steel metal-sheath probes include our 5610-6 and 5610-9 immersion probes, as well as our 5665 fully immersible probe. These probes are great for measuring in air, liquid or soil.

Silicone coated thermistor

With a diameter at the tip of just 1.5 mm (0.06 in), the 5611A's tip has the smallest diameter of any of our secondary reference thermistors and can fit nearly anywhere. Its faster response time, flexible sheath, and silicone coating make the 5611A great for use in many applications. However, applications involving silicone oil could damage the thermistor and should be avoided.

Higher performance

All of Hart's secondary reference thermistors have small diameters and very small sensing elements, which means they require far less immersion than a PRT to avoid errors caused by stem effect. Self heating is usually negligible, giving them an advantage when taking measurements in air. Their small size also improves response time, allowing measurements to be taken more quickly.

If your application involves frequent handling, you'll be especially interested to know thermistors are less susceptible to mechanical shock than PRTs. The bottom line may be better accuracy in fieldwork.

Additionally, higher base resistance and larger resistance coefficients make it easier to achieve precision readings with thermistors, so better resolution and accuracy are possible for a lower cost. All of these thermistors have a negative temperature coefficient of resistance (NTC). For additional information about thermistors, please see "Thermistors: the under-appreciated temperature standards" on page 76.)

Readouts

These probes come in a complete assembly ready for use, and each works well with the uncertainties of our thermometer readouts: the 1504 Tweener, the 1521 and 1522 Handheld Thermometers, the 1529 Chub-E4, the 1560 *Black Stack,* and the 1575A and 1590 Super-Thermometers.

These probes provide most accurate readings when coupled with a 2563 Standards Thermistor Module or 1590 Super-Thermometer, but they are most portable when used with a 1521 Little Lord Kelvin.

Calibrated accuracy

What's more, the Secondary Reference Series Thermistors are accurate to ± 0.01 °C and cover the temperature range of 0 °C to 100 °C. They come with a NIST-traceable calibration and a resistance-versus-temperature table printed in 0.1 °C increments that can be interpolated to 0.0001 °C. NVLAP accredited calibrations as single thermistors or as systems combined with their readouts, are also available.

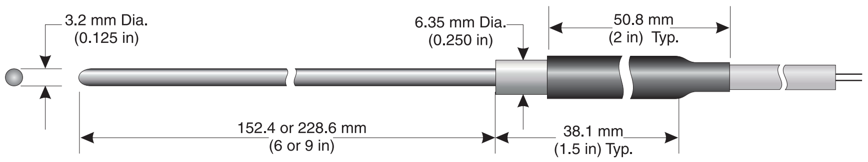
No other sensors can match the accuracy and price combination of these high-accuracy thermistor probes. Try one and you'll agree.

Secondary Reference Thermistor Probes

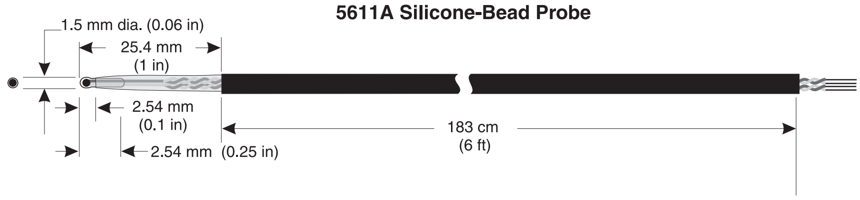
Specifications

Resistance	Nominal 10,000Ω at 25 °C
Range	0 °C to 100 °C
Calibration	R vs. T table with 0.1 °C increments, interpolation equation furnished
Calibration Uncertainty	Table and equation are accurate to ±0.01 °C
Drift	Better than ±0.01 °C per year
Repeatability	Better than ±0.005 °C
Size and Construction	See illustrations below.
Termination	Specify when ordering.

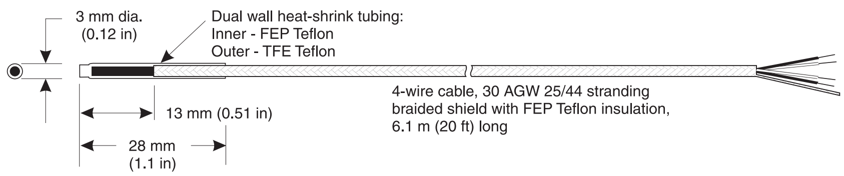
5610 Stainless Steel Immersion Probe



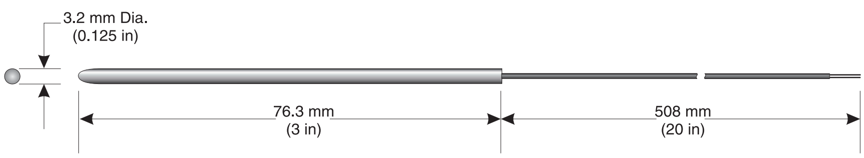
5611A Silicone-Bead Probe



5611T Teflon Probe



5665 Stainless Steel Miniature Immersion Probe



Ordering Information

5610-6-X	152 mm (6 in) Immersion Probe
5610-9-X	229 mm (9 in) Immersion Probe
5611A-11X	Silicone-Bead Probe
5611T-X	Teflon Probe
5665-X	Miniature Immersion Probe
1925-A	Calibration, 100 ° span, 6 points over span, NVLAP-accredited
1935-A	System calibration, 100 ° span, 6 points over span, NVLAP-accredited
2601	Probe Carrying Case

X = termination. Specify "B" (bare wire), "D" (5-pin DIN for Tweener Thermometers), "G" (gold pins), "I" (INFO-CON for 1521 or 1522 Handheld Thermometers), "J" (banana plugs), "L" (mini spade lugs), "M" (mini banana plugs), or "S" (spade lugs).

Handle your probe correctly

Good thermometer handling procedures help maintain calibration accuracy. Here are a few pointers.

Don't

- Don't subject a PRT to physical shock or vibration.
- Don't bend a probe that is not designed for bending.
- Don't subject a thermometer to sudden extreme temperature changes.
- Don't install compression fittings on a probe sheath.
- Don't subject a thermometer to temperatures outside its range.
- Don't subject a thermometer's transition junction, handle, or lead wires to temperatures outside their ranges (which likely differ from the thermometer's range).
- Don't immerse the probe past the bottom of its handle.

Do

- Do immerse a probe to at least its minimum immersion depth.
- Do allow the thermometer time to stabilize before taking readings.
- Do use the proper current to prevent self-heating errors.
- Do check your probe's R_{TPW} value frequently.
- Do test the shunt resistance of your probe periodically. (Shunt resistance is the resistance between the probe sensor and the probe sheath.)

Thermistors: the under appreciated temperature standards

Reprinted from *Random News*

Thermistors don't make good temperature standards? Yes they do. You've probably seen sensor comparison charts published by magazines and probe manufacturers. They're typically found in articles and application notes intended to help you select the correct sensor for various applications. In thermistor charts you regularly find the authors listing poor linearity and poor long-term stability as disadvantages. These are the reasons you most often hear repeated when someone believes a thermistor isn't a good thermometry standard.

Linearity

Let's look at non-linearity first. With today's powerful microprocessor-based readouts, non-linearity isn't really an issue. As long as the resistance vs. temperature curve of the sensor is very predictable, or repeatable, the sensor can make accurate measurements when used with a readout designed to deal with the non-linearity. The Steinhart-Hart equation or resistance look-up tables are commonly used by instruments to accurately convert resistance to temperature.

Stability

Poor long-term stability has been the main concern about thermistors. Changes in the physical composition of the semiconductor can result in either an increase or a decrease in the resistance of the thermistor. Oxidation of the semiconductor materials contributes to this change. For example, a common additive in thermistors is copper oxide, which has poor stability in the presence of oxygen. Problems with changing contact resistance sometimes result from thermal stress or insufficient strain relief between the thermistor body and its leads.

While these potential problems occasionally occur in the lower-cost thermistor devices, they are not common in thermistors which are hermetically sealed in glass. Sealing the thermistor eliminates oxygen transfer to the semiconductor and prevents resistance shifts. The rate at which the resistivity of a thermistor will change in the presence of oxygen increases with increasing temperature. Consequently, the use of a hermetic seal permits operation of the bead at higher temperatures. The glass seal also provides an adequate strain relief for the lead-to-ceramic contact on many thermistor styles.

NBS Study

Between 1974 and 1976, the National Bureau of Standards conducted a study on the stability of thermistors. The results demonstrated no significant drift for bead-in-glass thermistors. Non-glass-sealed disk type thermistors showed definite drift that increased as the test temperature increased. Later, J.A. Wise of the National Institute of Standards and Technology conducted another investigation that was published at the Seventh International Temperature Symposium in Toronto. Her study included newer, glass-sealed disk thermistors, as well as bead-in-glass thermistors. This time, the disk type faired nearly as well as the bead type.

These extensive studies conclude that a super-stable glass-sealed thermistor will typically drift only 0.001 °C to 0.002 °C per year. This level of stability is comparable, and, in fact better, than some SPRTs on the market today. However, a calibrated reference probe made with this type of thermistor costs between $500 and $1400 depending on its range and stability. An uncalibrated SPRT costs about $3,000. The thermistor probe is priced at the same level as a secondary PRT probe while delivering 10 to 20 times better annual stability.

Though many applications may not require high stability performance and many thermistors may not be suitable for standards thermometry, this does not mean all thermistors are not suitable. The same is true for platinum resistance thermometers. Most industrial RTDs are not suitable for standards work. This doesn't mean that a properly constructed PRT or SPRT is a bad standard.

Durability

Another interesting point is the fragility of the sensor. Sometimes thermistors are criticized as being too fragile. While a bare bead thermistor is fairly delicate, a properly constructed stainless steel-sheathed probe is surprisingly rugged when compared to a PRT or SPRT. The platinum resistance element in an SPRT or PRT is far more susceptible to mechanical shock than its thermistor counterpart. While the bumps and taps of everyday handling can impact the strain relief and contact resistance of the PRT, the same level of mechanical shock will not change the base resistance in a thermistor probe. The thermistor is recommended where frequent handling is expected.

Temperature range

The only real limitation of thermistors in metrology applications is temperature range. Currently, the most common ranges for super-stable thermistors suitable for metrology lie between 0 °C and 110 °C. Of course, a large percentage of all measurement applications fall between these two temperatures. An excellent strategy is to use a thermistor for work in this range and a PRT for work beyond that range. This reduces the handling of the PRT and the likelihood that a shift in base resistance will occur.

Other advantaes

Thermistors typically have larger base resistance and resistance change-per-degree than PRTs. This makes it easier to

Thermometer readouts

Model	ASL F250	Hart 1504 Tweener	Hart 1560 Black Stack	ASL F700	Hart 1575 Super-Thermometer	Hart 1590 Super-Thermometer	ASL F18
Thermistors?	No†	Yes	Yes	No†	Yes	Yes	No†
Meter Accuracy at 25 °C	±0.01 °C	±0.003 °C	±0.0013 °C	±0.001 °C	±0.00025 °C	±0.000125 °C	±0.0001 °C
Resolution	0.001 °C	0.0001 °C	0.0001 °C	0.00025 °C	0.000075 °C	0.00005 °C	0.0001 °C

†We realize this chart compares apples to oranges. That's because our competitors don't make thermistor readouts. So, to be fair, we've shown the best published specs from the closest competition. All their specs assume a 25Ω or 100Ω platinum resistance thermometer.

Thermistors: the under appreciated temperature standards

Hart's 1504 Tweener reads thermistors accurately to ±0.003 °C.

read their resistance precisely. It also contributes to a thermistor's ability to provide better resolution than a PRT. It is common to get meaningful and repeatable readings of temperature change to 5 places past the decimal.

The size of a thermistor bead is also considerably smaller than the size of a PRT. In a stainless steel sheath, the thermistor is much less affected by stem-conduction than a PRT. In many applications, a large PRT probe is simply too large. For example, the testing or calibration of biomedical devices and analytical instruments frequently requires a sensor smaller than even the bare PRT element, not to mention its tubular packaging. Off-the-shelf thermistor standards are available in diameters of only 1.8 mm (0.07 in) with small gauge leads. Tremendous flexibility is possible in custom packaging thermistors for surface, air, and liquid measurements.

While Hart manufactures reference PRTs and SPRTs, we do not make thermistors. Still, we feel it's important to promote their virtues because their unique advantages can contribute significantly to metrology and calibration work. For this reason, each of Hart's thermometer readouts is available with the ability to read thermistors. When you're considering the purchase of a readout, check into the possibility of reading thermistors. If the salesman tells you a thermistor isn't a good standard, you've just had a good indication of the company's credibility.