

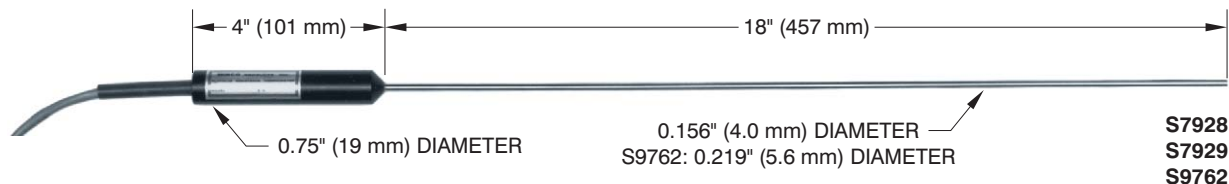


## Section 12: Precision Reference Thermometers

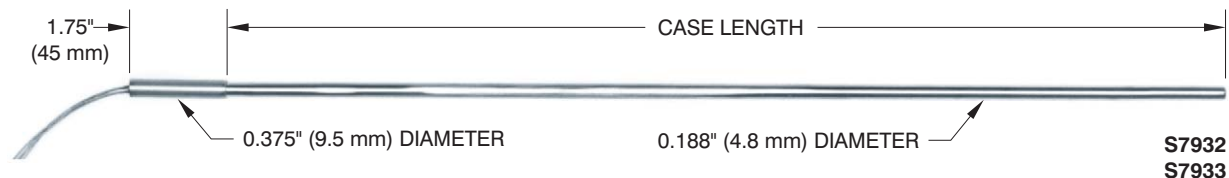
- Laboratory accuracy from -260 to 660°C (-436 to 1220°F)
- True strain-free elements
- Reference grade accuracy at affordable prices
- Traceable to NIST (National Institute of Standards and Technology)

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# Reference Thermometers



Leads: Shielded cable, 4 wires plus ground, 6 ft. (1.8 m) long



## Laboratory Standards

Stability	Repeatability after cycling	Temperature range	Sheath	Maximum temperature at leads	Insulation resistance (100 VDC)	Time response (water; 3ft/sec)	Self-heating (water; 3ft/sec)	Model
<b>Reference standards (air filled element)</b>								
0.005°C/yr.	0.005°C	-189 to 500°C (-308 to 932°F)	SS	60°C (140°F)	1000 MΩ	10 sec.	12.5 mW/°C	S7929PA S7928PJ
0.010°C/yr.	0.010°C	-50 to 250°C (-58 to 482°F)	SS	60°C (140°F)	100 MΩ	10 sec.	12.5 mW/°C	S7932PA S7932PJ
<b>Ruggedized standards (powder filled element)</b>								
0.050°C/yr.	0.025°C	-189 to 660°C (-308 to 1220°F)	Inconel	150°C (302°F)	1000 MΩ	9 sec.	80 mW/°C	S9762PA S9762PJ
0.030°C/yr.	0.020°C	-50 to 250°C (-58 to 482°F)	SS	60°C (140°F)	100 MΩ	8 sec.	80 mW/°C	S7933PA S7933PD

### Reference standards

- Air filled strain-free element
- S7928, S7929: 0.005°C stability from -189 to 500°C (-308 to 932°F)
- S7932: Reduced range for lower cost

Maintain an NIST-traceable secondary temperature reference in your calibration lab. These PRTs offer precision approaching that of primary standards at a fraction of the cost.

Thermometers are shipped in padded carrying cases. Like all temperature standards, they must be handled with extreme caution to avoid calibration shifts.

### Ruggedized standards

- Powder filled strain-free element
- S9762: 0.01°C stability to 600°C
- S7933: Reduced range for low cost

Ruggedized PRTs have a powder filled element to better withstand rough handling, at the cost of slightly reduced stability. They make excellent working standards for transferring calibrations in production environments. Model S9762 features an Inconel sheath for high temperature use.

### Platinum element options

Code	R(0°C)	TCR (Ω/Ω/°C)
PA	100 Ω	0.003925 min.
PD	100 Ω	0.003850
PJ	25.5 Ω	0.003925 min.

### How to order

S7928PJ	<b>Model number from table</b>
1	<b>1 = ±0.1% at 0°C</b>
L	
180	<b>Case length:</b> Specify in 0.1" increments (Ex:180 = 18.0") 18" min. required for custom calibration
S	<b>Leadwire termination:</b> S = 5 spade lugs G = 5 gold plated banana plugs C = 5-pin DIN connector
S7928PJ1L180S ← Sample P/N	

See page 12-6 for calibration.

# Reference Thermometers



## Cryogenic Capsule PRT

- Helium filled strain-free element
- 0.0025°C stability
- -260 to 260°C (13 to 533K)

Model S1059 is a miniature thermometer designed to cover a wide temperature range. It provides reference grade precision for cryogenics, calibration, and calorimetry.

Construction features include a strain-free element, gold-plated copper case, all-platinum internal components, dry helium backfill, and a platinum-to-glass internal seal. All materials are non-magnetic.

Select ice point resistance of 25.5 or 100 Ω. The higher resistance is recommended to reduce heat dissipation into cryostats.

### Specifications

Element	Model
Platinum, 25.5 Ω at 0°C	S1059PJ
Platinum, 100 Ω at 0°C	S1059PA

**Temperature coefficient:**  
0.003925 Ω/Ω/°C min.

**Case:** Gold-plated copper, helium filled, hermetically sealed. External lead connections epoxy potted.

**Leadwires:** True 4-wire lead construction. Four AWG 30 leads, polyimide insulation. 6" (150 mm) standard.

**Time constant:**  
4 seconds typical in water moving at 3 ft/sec.

**Self-heating:** Measuring power of 10 microwatts or less recommended to limit temperature rise to less than 0.6 mK.

**Repeatability:** ±0.0005°C typical after 20 cycles down to 4K.

**Stability:** ±0.0025°C/year at 0°C typical.

**Residual resistance:**  
 $\frac{R_{4.2K}}{R_{273.15K}} = 4 \times 10^{-4}$  typical

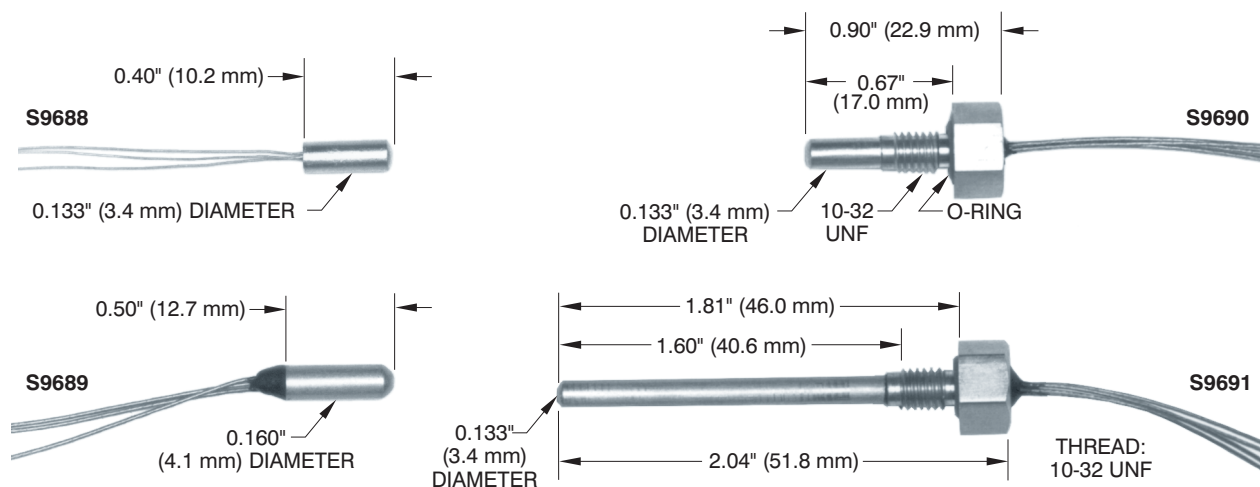
**Insulation resistance:** 1000 megohms min. at 100 VDC, leads to case, at 25°C.

### How to order

S1059PA	<b>Model number from table</b>
5	<b>5 = ±0.5% at 0°C</b>
X	<b>X = 4 leads</b>
6	<b>Lead length in inches:</b> 6" is standard
S1059PA5X6 ← Sample P/N	

See page 12-6 for calibration.

# Reference Thermometers



## Oil Filled Thermometers

- Oil filled strain-free element
- 0.02°C stability
- -60 to 204°C (-76 to 400°F)

The PRTs on this page use the same element construction as our laboratory thermometers but have an oil-filled, hermetically sealed case. The oil dampens vibrations to protect the sensing wire from stress and shocks. It also improves time response. You can obtain high precision measurements even in harsh industrial and aerospace environments.

### Specifications

#### Elements:

Element	Code
Platinum, 100 Ω at 0°C	PA
Platinum, 470 Ω at 0°C	PL

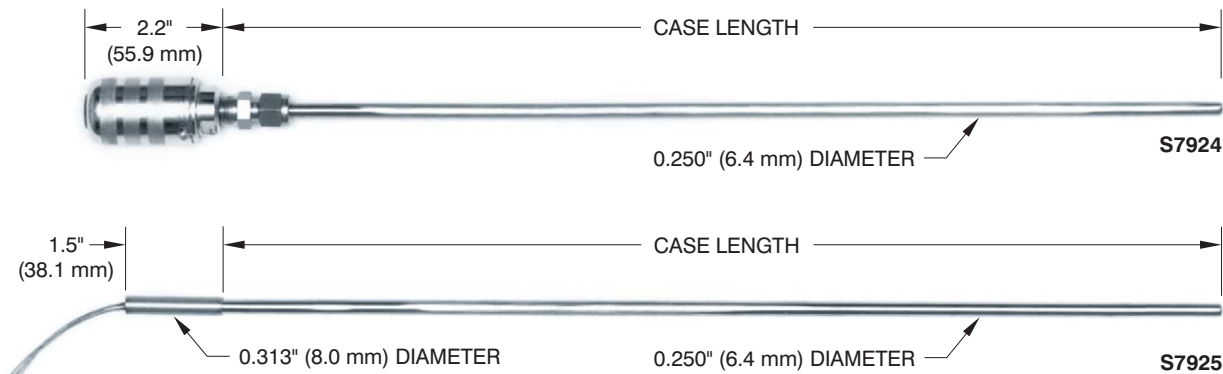
**Temperature coefficient:** 0.00392 Ω/Ω/°C min.  
**Case:** Gold-plated brass, oil filled, glass-to-metal hermetic seal, 3/8" (10 mm) hex. External lead connections epoxy potted.  
**Pressure rating:** 500 psi (34.5 bar) for threaded models.  
**Leadwires:** Three or four leads, stranded copper, AWG 30, polyimide insulation. 12" (305 mm) standard.  
**Time constant:** 1.6 seconds typical in water moving at 3 ft/sec.  
**Self-heating:** 30 mW/°C typical in water moving at 3 ft/sec.  
**Repeatability:** ±0.01°C after repeated cycling.  
**Stability:** ±0.02°C/year at 0°C typical.  
**Vibration:** Withstands 10 to 2000 Hz at 20 G's min. per MIL-STD-202, Method 204, Test Condition D.  
**Shock:** Withstands 100 G's min. sine wave shock of 8 milliseconds duration.  
**Insulation resistance:** 1000 megohms min. at 100 VDC, leads to case, at 25°C.

### How to order

S9689	<b>Model number (shown above):</b> S9688 S9689 S9690 S9691
PA	<b>Element code from table</b>
5	<b>Calibration tolerance at 0°C:</b> 1 = ±0.1% 5 = ±0.5%
X	<b>Number of leads:</b> Z = 3 leads X = 4 leads
12	<b>Lead length in inches:</b> 12" is standard Specify 0 for S9688
S9689PA5X12 ← Sample P/N	

See page 12-6 for calibration.

# Reference Thermometers



## Powder Filled Probes & Elements

- Powder filled strain-free element
- 0.05°C stability

Models S7924 and S7925 probes offer laboratory precision in rugged industrial environments. Use them for *in situ* process checks, calibration, and critical process control.

Model S7924 has a miniature connection head for termination of extension wires or cables. S7925 has built-in leadwires.

Field tests of the S7924 have shown performance superior to other commercially available thermometers. When used for side-by-side calibration of thermocouples in power plant equipment, the S7924 typically maintained stability within 0.01 to 0.03°C at 0°C, even after simultaneous exposure to high temperature and vibration.

Specify S215PA and S220PH powder-filled elements for 0.05°C stability at temperatures ranging from -250 to 650°C. Also see the 850°C elements on page 11-3.

Calibration options for these PRTs are on page 12-6.

### S7924, S7925 probes

Element	Model
Platinum, 100 Ω ±0.1% at 0°C	S7924PD
Platinum, 100 Ω ±0.1% at 0°C	S7925PD

**Temperature coefficient:** 0.00385 Ω/Ω/°C.

**Temperature range:** -189 to 540°C (-308 to 1004°F).

**Case:** 316 stainless steel, hermetically sealed. 4" minimum immersion recommended for best accuracy.

**Pressure rating:** 1000 psi (69 bar) at 20°C.

**Leadwire terminations:**

True 4-wire lead construction.

S7924: Steel terminal head with 4 screw posts for wires to AWG 14. Neoprene grommet and O-ring seal.

S7925: 36" (914 mm) AWG 26 leadwires, polyimide insulated.

**Time constant:** 9 seconds typical in water moving at 3 ft/sec.

**Self-heating:** 80 mW/°C typical in water moving at 3 ft/sec.

**Repeatability:** ±0.025°C after repeated cycling.

**Stability:** ±0.05°C/year at 0°C typical.

**Vibration:** Withstands 10 to 2000 Hz at 20 G's min. per MIL-STD-202, Method 204, Test Condition D.

**Shock:** Withstands 100 G's min. sine wave shock of 8 milliseconds duration.

**Insulation resistance:** 200 megohms min. at 25°C, 2 megohms min. at 500°C, 500 VDC, leads to case.

### How to order

S7924PD	<b>Model number</b>
120	<b>Case length:</b>
	60 = 6.0" 120 = 12.0"
	180 = 18.0" 240 = 24.0"
	18" min. required for custom calibration
S7924PD120 ← Sample P/N	

### S215PA, S220PH elements

Element	Model
Platinum, 100 Ω ±0.1% at 0°C	S215PA
Platinum, 500 Ω ±0.1% at 0°C	S220PH

**Temperature coefficient:** 0.00392 Ω/Ω/°C.

**Temperature range:** -250 to 650°C (-418 to 1202°F).

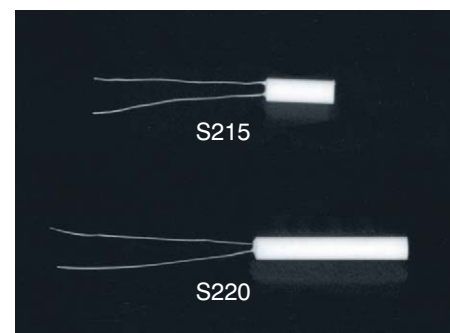
**Body material:** Ceramic.

**Leads:** 0.010" (0.25 mm) diameter platinum (S215) or platinum alloy (S220), 1" (25 mm) long.

**Repeatability:** ±0.05°C typical.

**Stability:** Drift less than 0.05°C/year in normal use.

Dimensions in inches (mm)		Model
Length	Diameter	
0.40 (10.2)	0.140 (3.56)	S215PA
0.90 (22.9)	0.140 (3.56)	S220PH



Reference  
PRT's

# Reference Thermometers

## Calibration

Minco's fully equipped standards lab can calibrate and furnish individual tables for any thermometer in this bulletin. All temperatures are based on ITS-90. There are two types of calibration:

### Fixed point calibrations

These calibrations use measurements taken at points derived from physical constants, such as the triple point of water or the freezing point of tin. The observed values are used to calculate coefficients for the interpolating equations of ITS-90. In addition to the complete R vs T table, Minco furnishes the actual fixed point values and the resulting coefficients.

### Comparison calibrations

Used for oil filled thermometers, comparison calibrations match the thermometer to be measured against an NIST traceable standard, rather than fixed points.

### Absolute vs ratio tables

Tables may list either absolute resistance values ( $R_T$  vs T) or resistance ratios ( $R_T/R_0$  vs T) indexed to 1. For example, if the absolute values of a thermometer are  $177.47 \Omega$  at  $200^\circ\text{C}$  and  $100.08 \Omega$  at  $0^\circ\text{C}$ , the ratio table reads 1.77328 at  $200^\circ\text{C}$ . A ratio like this tends to remain more stable over time than an absolute resistance. You can periodically recheck  $R_{0^\circ\text{C}}$  in an ice bath and use the latest value for ratio calculation.

### RTD calculations

Minco offers "SensorCalc", an on-line tool for creating, printing and saving RTD tables available at [www.minco.com/support](http://www.minco.com/support).

	Thermometer model (accuracy specifications may vary for other models)						
	S7928	S7929	S9762	S1059		S9688-S9691 S7932-S7933	S7924, S7925 <sup>3</sup>
Type of calibration	Fixed point	Fixed point	Fixed point	Fixed point		Comparison	Fixed point
Temperature range	-189 to $500^\circ\text{C}$	-189 to $500^\circ\text{C}$	-189 to $660^\circ\text{C}$	-269 to $260^\circ\text{C}$	-189 to $260^\circ\text{C}$	-100 to $200^\circ\text{C}$	-189 to $540^\circ\text{C}$
<b>Ordering number for tables</b>							
$R_T$ vs T, $1^\circ\text{C}$ increments	RT05	RT05	RT16		RT01	RT09	RT12
$R_T/R_0$ vs T, $1^\circ\text{C}$ increments	RT06	RT06	RT17		RT02	RT10	RT13
$R_T$ vs T, $0.1^\circ\text{C}$ increments		RT07	RT18	RT11 <sup>1</sup>	RT03		RT14
$R_T/R_0$ vs T, $0.1^\circ\text{C}$ increments		RT08	RT19		RT04		RT15
Table accuracy	$\pm 0.025^\circ\text{C}$	$\pm 0.025^\circ\text{C}$	$\pm 0.025^\circ\text{C}$	$\pm 0.025^\circ\text{C}$	$\pm 0.025^\circ\text{C}$	$\pm 0.035^\circ\text{C}$	$\pm 0.025^\circ\text{C}$
<b>Data points supplied</b>							
$-268.95^\circ\text{C}$ (4.2K): BP helium					•		
$-189.34^\circ\text{C}$ : TP of argon <sup>2</sup>	•	•	•		•		•
$-50^\circ\text{C}$ , $-25^\circ\text{C}$ , $175^\circ\text{C}$ <sup>2</sup>						•	
$-38.83^\circ\text{C}$ : TP of mercury <sup>2</sup>	•	•	•		•		
$0.01^\circ\text{C}$ : Triple Point of water	•	•	•		•	•	•
$100^\circ\text{C}$ : BP water <sup>2</sup>					•	•	
$231.928^\circ\text{C}$ : FP tin	•	•	•		•		•
$419.527^\circ\text{C}$ : FP zinc	•	•	•				•
$660.323^\circ\text{C}$ : FP aluminum <sup>2</sup>			( $\pm 0.05^\circ\text{C}$ )				

<sup>1</sup> Cryogenic calibrations available on special order.

<sup>2</sup> Comparison calibration measurement.

<sup>3</sup> S7924, S7925 calibrations based on EN60751, not ITS-90

## The Minco strain-free element

Minco precision thermometers rely on a unique element design for superior precision. It consists of a helical coil of platinum wire, spiraled onto a grooved ceramic bobbin. This construction gives more support to the coils than "birdcage"

designs, but does not stress the element during thermal expansion. The result is stable and repeatable measurements under a variety of conditions.

