Thermocouple (wire)	RTD (element)
Millivolt output (proportional to temperature), using two dissimilar metal wires	Generates a resistance (proportional to temperature), with an applied current to a Resistance Temperature Detector or element

What Type of Element

Thermocouple	RTD
GP - Type J, K, T, N, E	GP Class B
Higher Accuracy: Type JJ, KK, TT, NN, EE	High Accuracy: Class A
	Very High Accuracy: Class A+/1700

Other Selection Options

Option	Thermocouple (Junction Type)	RTD (Wire Type)
Basic Design	2 wire- Grounded, Ungrounded and Exposed	3 wire - Std 4 wire - Best Accuracy
# of elements per sheath	Single or Dual	Single or Dual
Connection Head	XP, Flip Top, GP Threaded Standard or 316SS	XP, Flip Top, GP Threaded Standard or 316SS
Sheath OD	1/4" Typical	1/4" Typical
Sheath Material	316SS Std	316SS Standard
Transmitter Options	(2) Programmable & Hart	(3) Two Programmable & Hart
Extension Wire	Must match T/C element type	Standard Copper Instrument Wire

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Summary of T/C and RTD

Thermocouple (T/C)	RTD
Use for higher temperatures (over 1000° F) or very fast response	Best accuracy and stability in most process applications below 900°F. (Comparable in price today with T/C.)

Thermocouples

- Higher Temperature Range (-320 to +2400°F)
- More Rugged (MI cable construction)
- Fast Response Time

.....But.....

- Requires matched extension wire to the element type used
- Worse accuracy at temperatures below 1000° F
- More short & long term drift

RTD's

- Best accuracy & repeatability
- Long term stability
- Sensor failures result in known failure mode -no drift like a T/C
- No special extension cable like T/C for longer runs -

.....But.....

- Slower response time
- Not as rugged. (Note for hi vibration - use PM construction - made of MI cable like thermocouple)

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Temperature Sensor Fundamentals

TEMPERATURE SENSORS

Thermocouples

Standard Calibration		Material	Temp. Range	Accuracy	Premium Grade	Accuracy
J	+	Iron	32°F to 1400° F	±4°F or 0.75%	JJ	±2°F or 0.40%
	-	Constantan				
K	+	Chromel	32°F to 2300° F	±4°F or 0.75%	KK	±2°F or 0.40%
	-	Alumel				
T	+	Copper	-320°F to 700°F	±2°F or 0.75%	TT	±1°F or 0.40%
	-	Constantan				
E	+	Chromel	32°F to 1600°F	±3°F or 0.75%	EE	±1.8°F or 0.40%
	-	Constantan				
N	+	Nicrosil	32°F to 2300°F	±4°F or 0.75%	NN	±2°F or 0.40%
	-	Nisil				

Shown is Smart Sensors' Mineral Oxide insulated thermocouple cable with a cutaway of the three most common junctions, (from left) ungrounded, exposed, and grounded. The data below may help you decide which size thermocouple is best. Response time is in seconds and measures a 63.3% step change in temperature from ambient to boiling water.

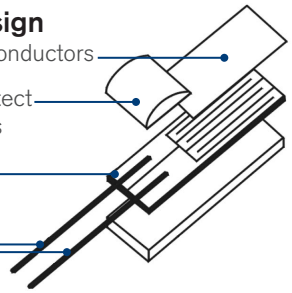
Measuring Junction Typical Response Time

Sheath OD	Measuring Junction	Response Time*
.063 (1/16")	Grounded	0.09
	Ungrounded	0.28
.125 (1/8")	Grounded	0.34
	Ungrounded	1.6
.188 (3/16")	Grounded	0.7
	Ungrounded	2.6
.250 (1/4")	Grounded	1.7
	Ungrounded	4.5
	Exposed Tip	0.09

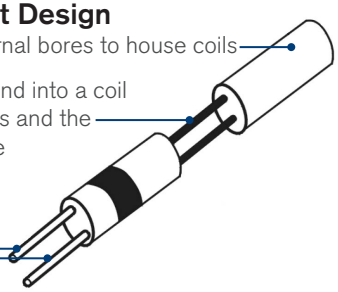
*Sensors not in thermowell or protection tubes

RTDs

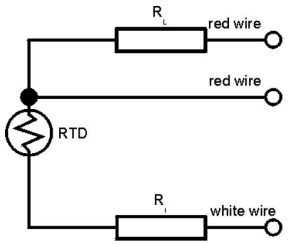
Film Style Element Design



Wire Wound Element Design

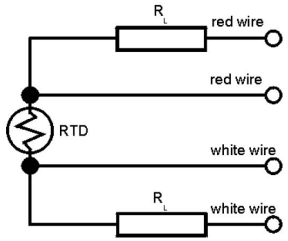


Three Wire RTD



Three-wire RTDs compensate for resistance resulting from length differences by adding a third lead to the RTD. To accomplish this requires that the wires match exactly. Any difference in resistance between the lead wires will cause an imbalance, which will compromise the accuracy of the RTD. Lead length variance, work hardening or corrosion, and manufacturing irregularities are errors to avoid. Quality manufacturing is critical to insure balance of all three leads.

Four Wire RTD



Errors caused by resistance imbalance between leads are cancelled out in a four-wire RTD circuit. Four-wire RTDs are used where superior accuracy is critical or if the sensor is installed far from the receiving device. In a fourwire RTD one pair of wires carries the current through the RTD the other pair senses the voltage across the RTD.

RTD Characteristics

Stability Defined as the ability of a sensor to maintain its stated accuracy over an extended period of time, usually one year, at its rated temperature. RTDs when used properly maintain stability much greater than thermocouples.

Repeatability Defined as the ability to repeat the same output value at a given temperature point in a spanned temperature range. Depending on the process conditions, RTDs typically are repeatable to ± .14° or .05%, whichever is greater.

Response Time Measured as the time necessary for a sensor to report a 63.3% step change in temperature in water moving transverse to the sensor sheath at 3 fps.

Sheath Diameter	Response Time
1/8"	2 Seconds
3/16"	3 Seconds
1/4"	5 Seconds

Accuracy The industry has standardized on two types of accuracy for Platinum 100 Ohm RTD elements. They are Class B, Class A. The table below shows typical element accuracies per DIN 60751.

Platinum (100 Ohm) Typical Accuracy

Temperature		Class B Standard		Class A High	
C	F	C	F	C	F
-100	-148	0.8	1.44	0.35	0.63
0	32	0.3	0.54	0.15	0.27
100	212	0.8	1.44	0.35	0.63
200	392	1.3	2.34	0.55	0.99
300	572	1.8	3.24	0.75	1.35
400	752	2.3	4.14	0.95	1.71
500	932	2.8	5.04	1.15	2.07