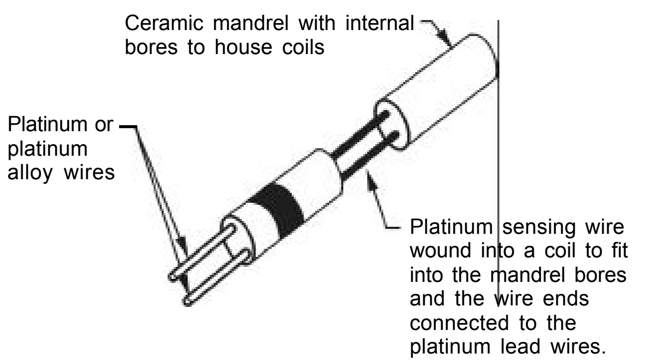
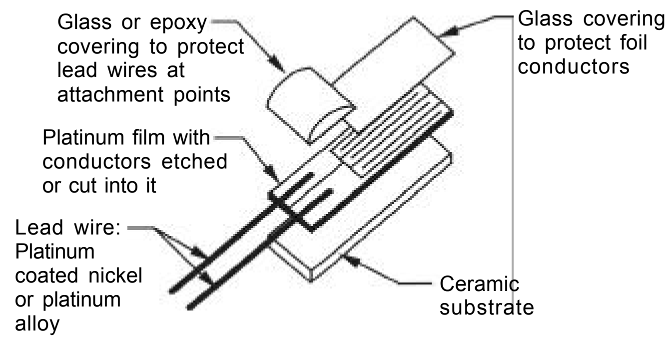
Specifying RTDs

Wire Wound Element Design



Film Style Element Design



A resistance temperature detector (RTD) operates on the principle that electrical resistance of metal changes as its temperature changes. The resistance of the sensing element increases as the temperature rises. There are two basic RTD designs wire wound and thin film. Wire wound design is a platinum sensing wire wound into a coil and housed in a ceramic mandrel to protect the coil. The thin film design consists of platinum deposited on a ceramic substrate and trimmed to achieve the desired alpha the construction is then covered with glass and epoxy to protect platinum film. Thin films are manufactured much in the same way as computer chips

The metal that is employed in a RTD must change resistance with respect to temperature and provide stability and a high output. The three metals that best exhibit these characteristics are:

Platinum
The stability and linearity of this metals' resistive output over a broad range makes it the best metal for process type RTD's. Platinum can withstand oxidation and is effective over a range of –200 to + 850 degrees C. The four basic ohm values of 100, 200, 500 and 1000 give the user different degrees of sensitivity within the sensor. The higher the ohm value the greater the sensitivity and resolution. See chart on page 8 for the resistance change per degree Celsius for the temperature coefficient of resistance (TCR) for the RTD you are using.

Copper
The greatest strength of this metal is its low cost. Copper performs poorly in oxidizing atmospheres and has a low output and thus an inability to perform in narrow measuring spans.

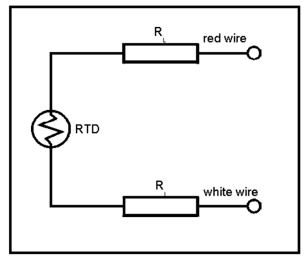
Nickel
This metal is a good compromise between copper and platinum. It has a higher output and is slightly less expensive than platinum. It is extremely nonlinear above 300 degrees C.

RTDs are known for their excellent accuracy and linearity over a wide temperature range. Some RTDs have accuracies as high as 0.01 ohms (0.026°C) at 0°C. RTDs are also extremely stable devices. Common industrial RTDs drift less than 0.1°C/year. Manufacturing processes increasingly require precise process control. For this reason the number of RTDs installed annually continues to grow as a percentage of total temperature sensor sales.

Because an RTD is a passive resistive device, you must pass a current through the device to produce a measurable voltage. This current causes the RTD to internally heat, which appears as an error. You can minimize self-heating by using the smallest possible excitation current. The typical RTD receiving device uses 1mA to stimulate the RTD.

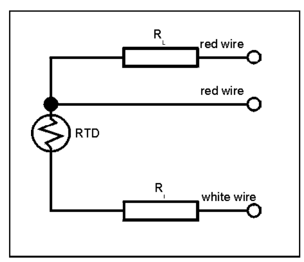
RTDs are available in two-, three-, and four-wire configurations. The number of lead wires directly affects such factors as accuracy, stability, installation budget and distance between sensor and receiver.

Two Wire



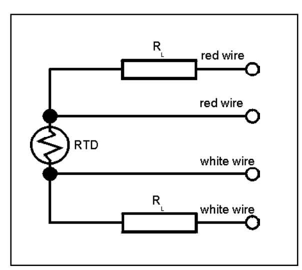
When accuracy is not critical, a two-wire RTD is the least expensive; offering. Using lead wires to place any distance between a two-wire RTD and a receiving device will further compromise its accuracy. The potential for poor accuracy from a two-wire RTD stems from its inability to compensate for lead length, resistance that changes the ohm value of the original signal. A two-wire RTD should be used only in applications where the receiving device connects directly to the sensor.

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 four-wire RTD one pair of wires carries the current through the RTD the other pair senses the voltage across the RTD. 2- and three-wire RTDs require heavier lead wire because thicker wire, by creating less resistance to the measured signal, reduces measurement distortion. Therefore lighter gauge wire, less expensive, may be used in four-wire RTD applications.

RTDs are limited to temperatures of 1200 ° F and because of the construction of the sensing element, RTDs do not do well in high-vibration and severe mechanical shock environments. When selecting a temperature sensor for an application you should consult your temperature sensor manufacturer for recommendations.

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 can maintain a stability of .25°

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

Response Time: Measured as the time necessary for a sensor to report a 63.2% 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, the standard in the process industry and the higher accuracy Class A. The table below shows typical element accuracies per DIN 43760-1980 and ASTM E1137.

Platinum (100 ohm)

Temperature		Accuracy Class B Standard		Class A High	
°C	°F	°C	°F	°C	°F
-100	-148	.8	1.44	.35	.63
0	32	.3	.54	.15	.27
100	212	.8	1.44	.35	.63
200	392	1.3	2.34	.55	.99
300	572	1.8	3.24	.75	1.35
400	752	2.3	4.14	.95	1.71
500	932	2.8	5.04	1.15	2.07

Standard Accuracy
Nickel (120 ohm)

Rt	Temperature		Tolerance		
(°C)	°C	°F	±°C	±°F	±ohms
70.83	-73	-100	1.25	2.25	.825
120.00	0	32	.83	1.50	.600
148.07	38	100	1.30	2.34	1.020
200.64	100	212	2.10	3.76	1.910
247.82	149	300	2.68	4.75	2.700
380.31	260	500	4.28	7.71	5.520

Optional High Accuracy
Nickel (120 ohm)

Rt	Temperature		Tolerance		
(°C)	°C	°F	±°C	±°F	±ohms
70.83	-73	-100	.84	1.52	.55
120.00	0	32	.56	1.00	.40
148.07	38	100	.88	1.58	.68
200.64	100	212	1.39	2.51	1.27
247.82	149	300	1.79	3.23	1.82
380.31	260	500	2.62	4.71	3.68

Standard Accuracy - Copper
(9.035 ohms @ 0 °C / 10 ohms @ 25 °C)

Rt	Temperature		Tolerance		
(°C)	°C	°F	±°C	±°F	±ohms
6.190	-73	-100	2.83	5.09	.112
9.035	0	32	1.14	2.05	.045
10.000	25	77	1.56	2.80	.056
10.490	38	100	2.12	3.82	.084
12.897	100	212	3.53	6.36	.196
14.780	149	300	4.94	8.90	.140
19.116	260	500	7.78	14.00	.308

Optional High Accuracy - Copper
(9.035 ohms @ 0 °C / 10 ohms @ 25 °C)

Rt	Temperature		Tolerance		
(°C)	°C	°F	±°C	±°F	±ohms
6.190	-73	-100	1.04	1.87	.040
9.035	0	32	.44	.73	.016
10.000	25	77	.56	.100	.020
10.490	38	100	.66	1.19	.030
12.897	100	212	1.25	2.25	.050
14.780	149	300	1.72	3.09	.070
19.116	260	500	2.74	4.94	.011

Temperature Coefficient of Resistance (TCR)

The temperature coefficient of a sensor is determined by the purity of the winding wire used in the manufacture of the sensor element. It is defined as the resistance change per ohm per degree C. Our standard RTDs use the following TCRs:

Platinum = Curve A = .00392 ohms/ohm/°C
Curve B = .003850 ohms/ohm/°C
Nickel = .006720 ohms/ohm/°C
Copper = .004274 ohms/ohm/°C

Sensor Resistance Change per Degree at 0°C (32°F)

Sensor Resistance	°C	°F
100 ohm Platinum	.39 ohms	.22 ohms
200 ohm Platinum	.78 ohms	.44 ohms
400 ohm Platinum	1.56 ohms	.88 ohms
500 ohm Platinum	1.95 ohms	1.10 ohms
1000 ohm Platinum	3.90 ohms	2.20 ohms
120 ohm Nickel	.72 ohms	.40 ohms
10 ohm Copper	.039 ohms	.02 ohms
100 ohm Copper	.39 ohms	.22 ohms