Elements of several different materials, base resistances, temperature coefficients, accuracies, and construction styles are available for installation into final RTD temperature sensor assemblies to meet customer specifications. Pyromation's standard RTD constructions utilize both thin film and wire wound elements as specified by the part number. The temperature ranges are either dictated by the construction style or element type whichever is lower. These construction styles are listed below.

LOW RANGE - THIN-FILM CONSTRUCTION (L) (-40 to 200) °C [-40 to 392] °F
The element is welded to Teflon®-insulated, silver-plated copper leads, and then placed inside a specially-cleaned stainless steel sheath. The space surrounding the element and leads is filled and loosely packed with alumina oxide powder to provide good heat transfer times, and to provide a damping cushion against vibration and mechanical shock. The filled sheath is then sealed with low temperature epoxies to prevent moisture penetration.

LOW RANGE - WIRE-WOUND CONSTRUCTION (L) (-200 to 200) °C [-328 to 392] °F
The element is welded to Teflon®-insulated, silver-plated copper leads, and then placed inside a specially-cleaned stainless steel sheath. The space surrounding the element and leads is filled and loosely packed with alumina oxide powder to provide good heat transfer times, and to provide a damping cushion against vibration and mechanical shock. The filled sheath is then sealed with low temperature epoxies to prevent moisture penetration.

MEDIUM RANGE - THIN-FILM CONSTRUCTION (M) (-50 to 480) °C [-58 to 896] °F
The element is welded to fiberglass-insulated, nickel-plated copper leads, and then placed inside a specially-cleaned stainless steel sheath. The space surrounding the element and leads is filled and loosely packed with alumina oxide powder to provide good heat transfer times, and to provide a damping cushion against vibration and mechanical shock. The filled sheath is then sealed with low-temperature epoxies to prevent moisture penetration.

MEDIUM RANGE - THIN-FILM CONSTRUCTION (K) (-50 to 315) °C [-58 to 599] °F
The element is welded to Kapton®-insulated, nickel-plated copper leads, and then placed inside a specially-cleaned stainless steel sheath. The space surrounding the element and leads is filled and loosely packed with alumina oxide powder to provide good heat transfer times, and to provide a damping cushion against vibration and mechanical shock. The filled sheath is then sealed with low-temperature epoxies to prevent moisture penetration.

HIGH RANGE - WIRE-WOUND CONSTRUCTION (H) (-200 to 600) °C [-328 to 1112] °F
The element is welded to nickel leads that are insulated with compacted magnesium oxide (MgO) powder inside the stainless steel sheath. The void surrounding the element is packed with MgO powder and the sheath tip is welded closed with a stainless steel cap. The leads and sheath are sealed with low-temperature epoxies to prevent moisture penetration.

HIGH RANGE - THIN-FILM CONSTRUCTION (H) (-50 to 500) °C [-58 to 932] °F
The element is welded to nickel leads that are insulated with compacted magnesium oxide (MgO) powder inside the 316 stainless steel sheath. The void surrounding the element is packed with MgO powder and the sheath tip is welded closed with a 316 stainless steel cap. The leads and sheath are sealed with low-temperature epoxies to prevent moisture penetration.

RTD Element Terminology

TEMPERATURE COEFFICIENT OF RESISTANCE: The fractional change in element resistance per change of 1 °C , is expressed as Ω/Ω/ °C or $\Omega \cdot \Omega^{-1} \cdot {}^\circ C^{-1}$ or $^\circ C^{-1}$

TOLERANCE: Initial maximum allowable deviation expressed as $\Delta t(t)$ in °C from nominal temperature/resistance relationship R(t).

SELF-HEATING: Self-heating is the rise in the measured temperature caused by the power dissipated in the element. Self-heating error is affected by the thermal conductivity and velocity of the process being measured and is negligible for most applications.

THERMAL RESPONSE: The time a thermometer takes to respond at a specified percentage to a step change in temperature. To specify response time, it is necessary to declare the percentage of response, usually $\tau_{0.9}$, $\tau_{0.5}$, or $\tau_{0.1}$, which gives 90%, 50% or 10% of the response. The test medium and its flow conditions have to be specified (usually flowing water or flowing air).

MINIMUM IMMERSION DEPTH: Immersion depth at which the change from calibration at full immersion does not exceed 0.1 °C.

REPEATABILITY-STABILITY: The ability of an element to reproduce the same resistance or temperature reading each time it is at equilibrium at a given repeated temperature. Expressed as a ± resistance or temperature value over a given temperature range. This may also be expressed as the stability of its resistance. Typically platinum elements will not change more than 0.04% at 0 °C [32 °F] after receiving ten consecutive shocks from (-200 to 600) °C [-328 to 1112] °F.

VIBRATION: Pyromation's fully assembled sheathed RTD sensors are designed to withstand an average vibration level of 30 G's using random vibrating frequencies from (20 to 2,000) Hz at ambient temperature. Supporting test results indicate that initial RTD tolerances remain as specified when tested at these vibration levels.

HUMIDITY LIMITS: Sheaths, transition fittings, and lead seals capable of withstanding 100% humidity at normal atmospheric pressure, and at normal ambient temperatures.

INTERCHANGEABILITY: The amound of allowable difference in readings between two RTD's when placed side by side in a process at the same temperature. This is determined by the allowable RTD tolerance at that particular temperature.

Teflon® and Kapton® are registered trademarks of EI du Pont de Nemours and Company.

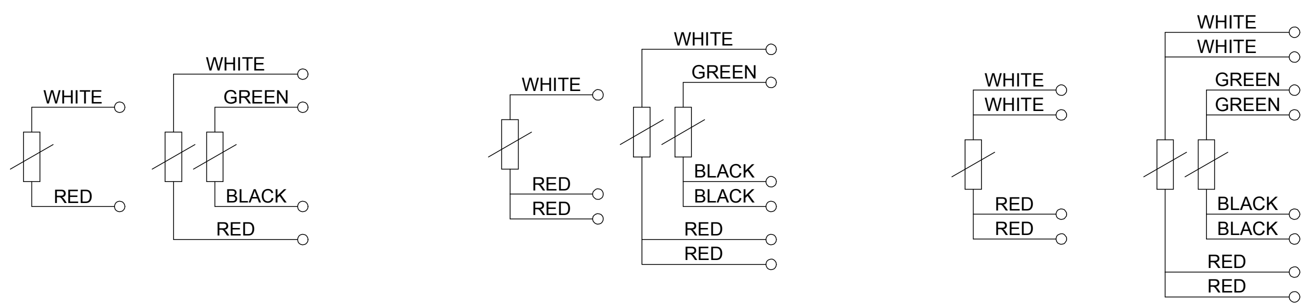
Element Connections

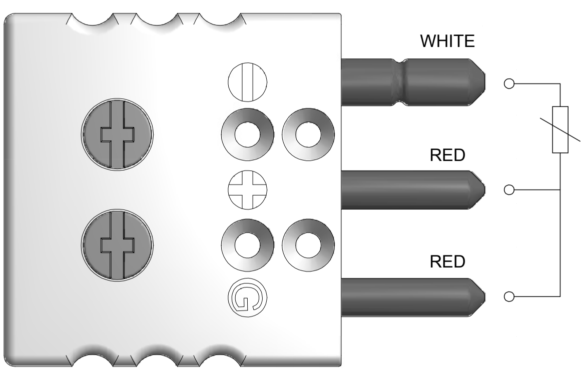
Two-Wire: Provides one connection to each end of the element. This construction is suitable where the resistance of the lead wire may be considered as an additive constant in the circuit, and particularly where the changes in lead resistance due to ambient temperature changes may be ignored.

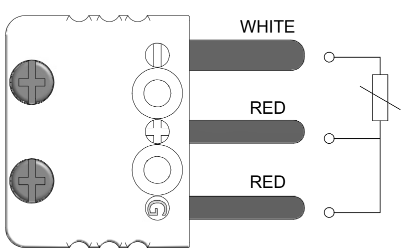
Three-Wire: Provides one connection to one end of the element and two to the other end of the element. Connected to an instrument designed to accept three wire input, sufficient compensation is usually achieved for leadwire resistance and temperature change in leadwire resistance. This is the most commonly used configuration.

Four-Wire: Provides two connections to each end of the element to completely compensate for leadwire resistance and temperature change in leadwire. This configuration is used where highly accurate temperature measurement is vital.

2-WIRE SINGLE **2-WIRE DUPLEX** **3-WIRE SINGLE** **3-WIRE DUPLEX** **4-WIRE SINGLE** **4-WIRE DUPLEX**







Lead resistance has a large effect on RTD temperature measurement accuracy. A 2-wire circuit provides no compensation and can provide large measurement errors. The following table shows the effects of leadwire resistance on temperature measurements using low-temperature RTD assemblies with copper leadwire.

Leadwire Resistance

LEADWIRE-WIRE GAUGE	RESISTANCE-OHMS PER FOOT	UNCOMPENSATED 2-WIRE CIRCUITS	
		MAX. LENGTH FOR 1 °F ERROR @ 20 °C [68 °F]	ERROR IN °F PER DOUBLE FT.
30	0.133	0.81 ft	1.24 °F
28	0.0851	1.26 ft	0.79 °F
24	0.0333	3.2 ft	0.31 °F
22	0.0213	5.1 ft	0.198 °F
20	0.0148	7.27 ft	0.14 °F
18	0.0083	13.0 ft	0.077 °F
16	0.0052	20.7 ft	0.048 °F

STANDARD PLATINUM RTD ASSEMBLIES - Pyromation standard RTD assemblies are constructed using either wire-wound platinum elements or thin-film elements with a reference resistance of 100 ohms at 0 °C, a temperature coefficient 0.003 85 °C^{-1} and which are in accordance with the following standards:

1. International Standard, IEC 60751 2. American Standard, ASTM E1137

TEMPERATURE		IEC CLASS B [1] ± (0.12% × R_O) Ω		ASTM GRADE B [1] ± (0.1% × R_O) Ω		IEC CLASS A [1] ± (0.06% × R_O) Ω		IEC CLASS AA [1] ± (0.04% × R_O) Ω		(1/5) IEC CLASS B [2] ± (0.02% × R_O) Ω	
		± (0.3 + 0.005 |t|) °C		± (0.25 + 0.0042 |t|) °C		± (0.15 + 0.002 |t|) °C		± (0.1 + 0.0017 |t|) °C		± (0.06 + 0.001 |t|) °C	
°C	[°F]	°C	[°F]	°C	[°F]	°C	[°F]	°C	[°F]	°C	[°F]
-200	[-328]			1.09	[1.96]	0.55	[0.99]	0.44	[0.79]	0.26	[0.47]
-100	[-148]			0.67	[1.21]	0.35	[0.63]	0.27	[0.49]	0.16	[0.29]
-50	[-58]	.55	[0.99]	0.46	[0.83]	0.25	[0.45]	0.19	[0.34]	0.11	[0.20]
0	[32]	.30	[0.54]	0.25	[0.45]	0.15	[0.27]	0.10	[0.18]	0.06	[0.11]
100	[212]	.80	[1.44]	0.67	[1.21]	0.35	[0.63]	0.27	[0.49]	0.16	[0.29]
200	[392]	1.3	[2.34]	1.09	[1.96]	0.55	[0.99]	0.44	[0.79]	0.26	[0.47]
300	[572]	1.8	[3.24]	1.51	[2.72]	0.75	[1.35]				
400	[752]	2.3	[4.14]	1.93	[3.47]	0.95	[1.71]				
500	[932]	2.8	[5.04]	2.35	[4.23]	1.15	[2.07]				
600	[1112]			2.77	[4.99]	1.35	[2.43]				

Where: |t| = value of temperature without regard to sign, °C
[1] The equations represent values for 3- and 4-wire PRTs. Caution must be exercised with 2-wire PRTs due to lead resistance.
[2] This tolerance can only be met with a 4-wire PRT.