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Resistance Temperature Detectors

I – THEORY OF OPERATION

An RTD's basis of operation lies in a common property of any metal, the relationship between its temperature and the resistance to the flow of electrical currents through it. Once the characteristics of this relationship were established, a few metals found their way into common use in RTD's. These are, mainly, platinum, nickel and copper.

Platinum's resistance changes relative to temperature, reflected in an RTD's TCR (temperature coefficient of resistance), is about 0.0039Ω/Ω/°C - sufficient for high sensitivity to temperature at the usual 100Ω nominal resistance. Linearity of the resistance/ temperature relationship is also quite good and well defined. And finally, accuracy is excellent due to platinum's stability and resistance to contamination, which also results in a wide recommended operating temperature range of -200 to 550°C.

The most common RTD, a platinum RTD as described above but modified for industrial applications, has a platinum alloy element (usually platinum - 5% rhodium) with a TCR of 0.00385Ω/Ω/°C and shares most of the characteristics of the platinum RTD with added durability and a recommended temperature range extended to 650°C.

Nickel and copper are also occasionally used as resistive elements in RTD applications. Nickel has the largest TCR at 0.00672Ω/Ω/°C for very high sensitivity but its linearity is very poor. Copper is the most linear, but has a limited temperature range.

II – RTD ELEMENT PARAMETERS

An RTD's sensing element has several parameters from which to select depending on the application:

Material (specification)	Platinum (IEC-751)	Platinum (JIS C1604-1989)	Copper	Nickel
TCR	0.00385 Ω/Ω/°C	0.003916 Ω/Ω/°C	0.00427 Ω/Ω/°C	0.00672 Ω/Ω/°C
Nominal Resistance	**100**, 500, or 1000Ω @ 0°C	**100**, 500, or 1000Ω @ 0°C	10Ω @25°C	120Ω @0°C
Accuracy	To ±(0.15+.002·|T|)°C	To ±(0.15+.002·|T|)°C	n/a	n/a
Temperature Range	-250 to 850°C	-250 to 650°C	-90 to 250°C	-90 to 300°C

(These are the most common values, additional TCR's, nominal resistances, and accuracy's are widely available)

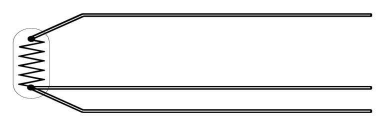
III – RTD LEAD CONFIGURATION

An additional consideration in the designation of RTD parameters is the lead configuration. Four possibilities exist:

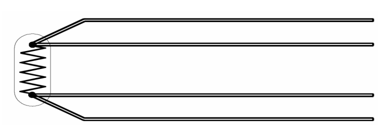
In the two-wire configuration, lead wire resistance can't be accounted for. This design is employed when accuracy is of less importance than other mechanical and/or electrical design parameters. Note, using an element with a high nominal resistance can minimize accuracy problems:

Approximate error induced by lead wire at room temperature for platinum RTD's

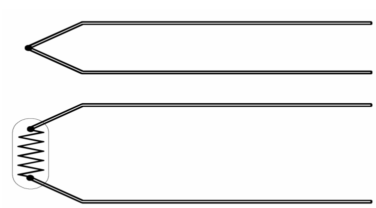
Lead length (24 AWG)	12"	24"	48"	120"
100Ω nominal resistance @ 0°C	0.13°C	0.27°C	0.53°C	1.33°C
500Ω nominal resistance @ 0°C	0.03°C	0.05°C	0.11°C	0.27°C
1000Ω nominal resistance @ 0°C	0.01°C	0.03°C	0.05°C	0.13°C



The most common configuration for industrial RTD's is the three-wire. Lead wire resistance is compensated for by the addition of a third leg. Accuracy is dependent on the matched resistances of the lead wires, errors induced by this configuration normally amount to less than 0.05°C



In the four-wire configuration, lead wire resistance is compensated for by the addition of third and fourth legs. Accuracy is no longer dependent on the matched resistances of the lead wires. This configuration also has better immunity to noise, thermoelectric effects, and contact resistance problems.



An uncommon variation of the three-wire configuration, with similar performance, but uses a separate circuit for the compensating loop.