Press Release

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Temperature sensors: Make the right choice, RTD vs. T/C

Temperature variances in the process industry can have a significant impact on profits, safety, and quality. A variety of industries and applications are affected that include Oil & Gas, Power, Refining, Petrochemical, Pharmaceutical, and more. Monitoring temperature accurately is depended upon several factors, including selecting the right sensor for the specific application and process.

Two of the most common temperature measurement devices are Resistance Temperature Detectors (RTDs) and thermocouples (T/Cs). The technology behind them is different, each having benefits that drive appropriate selection. An RTD is based on the principle that the electrical resistance of a metal increases as temperature increases – a phenomenon known as thermal resistivity.

In comparison, a thermocouple is a closed-circuit thermoelectric temperature sensing device consisting of two wires with dissimilar metals joined at both ends. A current is created when the temperature at one end or junction differs from the other end's temperature. This phenomenon is known as the Seebeck effect, which is the basis for thermocouple temperature measurements.

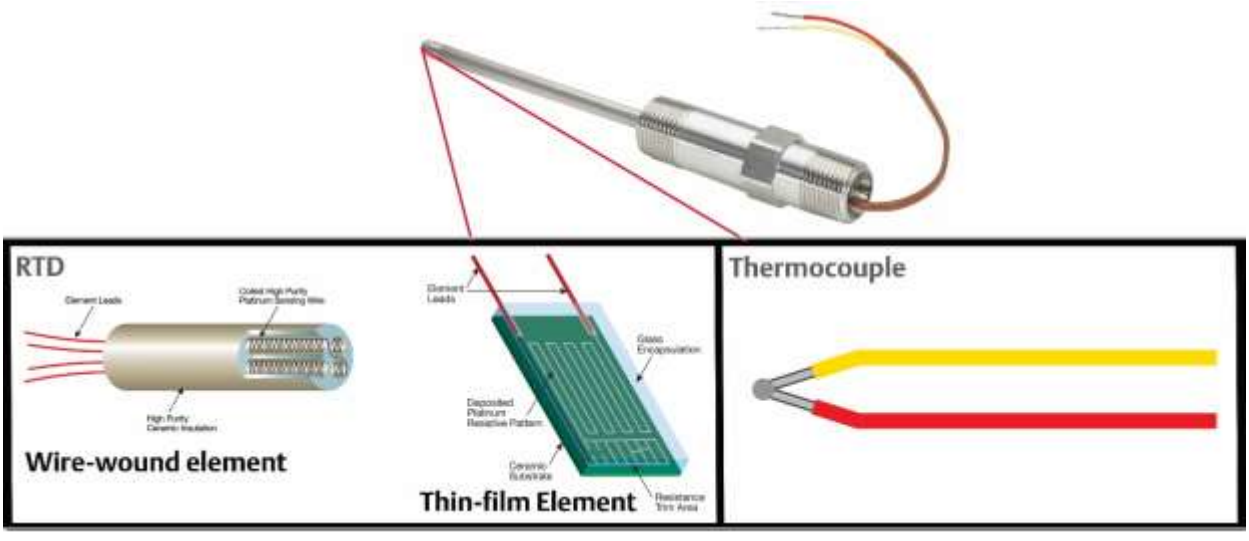
Comparing the differences

RTD's are constructed of resistive material with leads attached and is usually placed into a protective sheath. The resistive material may be platinum, copper, or nickel with the most common by far being platinum. The reason is its high accuracy, excellent repeatability, and exceptional linearity over a wide range. It exhibits a large resistance change per degree of temperature change. The two most common RTD styles of sensors are wire-wound and thin-film.

Wire-wound RTDs are manufactured either by winding the resistive wire around a ceramic mandrel or by winding it in a helical shape supported in a ceramic sheath – hence the name wire-wound. For thin-film RTDs, a thin resistive coating is deposited on a flat (usually rectangular) ceramic substrate. Thin-film RTDs are typically less expensive than wire-wound RTDs because fewer materials are needed for their construction.

RTDs are much more repeatable and have better sensitivity that T/Cs. The long-term drift of an RTD is predictable, while a T/C drift is erratic. It provides the benefit of less frequent calibration and, therefore, lower cost of ownership. Finally, RTDs provide excellent linearity. When coupled with the linearization performed in a quality transmitter, a precision of about 0.1 °C is possible, which is much better than what is possible with a T/C.

In comparison, a thermocouple (T/C) is a closed-circuit thermoelectric temperature sensing device consisting of two wires of dissimilar metals joined at both ends. The most common types are "J", which uses iron and Constantan, and "K", which uses Chromel and Alumel. Thermocouples have faster response times and higher temperature ranges than RTDs but are less accurate. Thermocouples have heavy gauge wire construction for durability and therefore, can withstand high vibration – see drawing and chart below.



The following chart compares the key sensor characteristics.

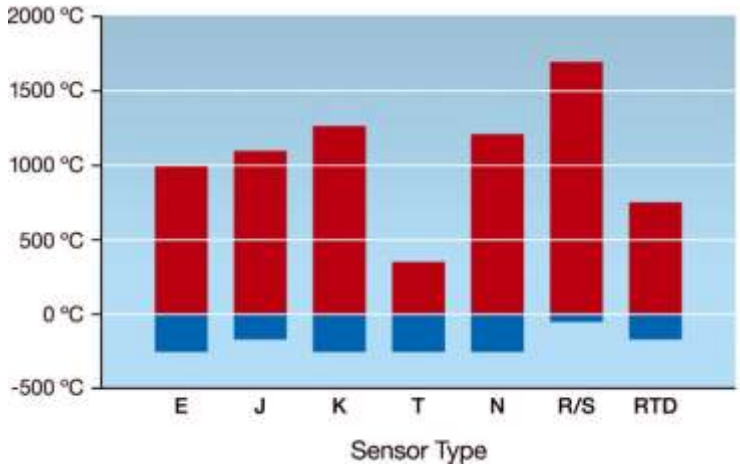
Attribute	RTD	Thermocouple
Accuracy Interchangeability	Class A: ± (0.15 + 0.002 |t|) Class B: ± (0.30 + 0.005 |t|) Per IEC 60751	Typical is ± 1.1 °C or ± 0.4% of measured temperature (Greater). Depends on Type and Range. Degraded by extension wire.
Stability	± 0.06 °C per 1000 Hrs at ≤ 300 °C. Greater at higher temperatures. Wire wound better than thin film.	Highly dependent on T/C type, quality of the wire and operating temperature. Typical is ± 2 to 10 °C per 1000 Hrs.
Speed of Response in Thermowell Installation in Liquid	For 6mm sensor about the same as T/C.	For 6mm sensor about the same as RTD. Slightly faster for 3mm sensor.
Calibration	Easily recalibrated for long service life. Best accuracy with Sensor-Transmitter Matching.	Limited to in situ comparison to "Standard T/C".
Potential Temperature Range	-200 to 850 °C	-270 to 2300 °C
Life Span	Many years. Shorter at higher temperatures.	Degradation indicates frequent replacement. Much shorter at high temperatures. Higher life cycle costs.
Installation Considerations	Use standard copper wire. Good EMI and RF immunity.	Requires expensive matching extension wire. Low level signal is very susceptible to EMI and RFI.
Vibration Tolerance	Thin film design is very good.	Larger wire diameters are very good.
Life Cycle Cost	Lower.	Higher.
Purchase Cost	Thin film design about the same. Wire wound higher.	Types R and S most expensive.
System Performance with Transmitter	Always better below 650 °C.	Order of magnitude lower.

Choosing the right sensor technology

When choosing the right sensor for your process and application there are a few basic questions that should be asked. The answers will provide valuable insight for selecting the appropriate sensor.

1. **What is the temperature range you are trying to measure?**

   When selecting a sensor, it is crucial to determine the correct temperature range. If the temperature is above 850°C, you must use a thermocouple. If it is below 850°C, you can select either an RTD or T/C. Also, keep in mind that wire-wound RTDs have a more extensive temperature range than thin-film RTDs – see chart below.



2. **What is your required sensor accuracy?**

   Determining the level of accuracy needed is also an important factor in the selection process. In general, RTDs are more accurate than thermocouples, and wire-wound RTDs are more precise than thin-film RTDs. Assuming no other factors drive the selection of one technology over the other, this guideline will help you find the most accurate sensor technology.

3. **Is process vibration a concern?**

   The amount of process vibration also needs to be considered when selecting a sensor. Thermocouples have the highest vibration resistance of all of the sensor technologies. If you have a known high vibration, thermocouples will give you the highest reliability. Thin-film RTDs are also resistant to vibration; however, they are not as robust. Wire-wound RTDs should not be used in high vibration environments.

The right choice = the best results

The overall key to success is asking basic questions and matching up the information with the right sensor for your applications and process. An example would be adding a temperature measurement to a pipeline where the measurement is under varying conditions with constant vibration and a process temperature variance of 200-300°C. Your goal is to have the best possible accuracy despite these challenges.

To determine what type of sensor to use, first consider the differences between thermocouples and RTDs. The temperature range makes both sensor technologies feasible for this application. T/Cs are known for their higher vibration tolerance, so at first glance, thermocouples would appear to be a good option. However, in this specific instance, the measurement requires the best possible accuracy. The right choice for this application would be a thin film RTD. Thin-film RTDs are known for their higher tolerance to vibration than wire-wound RTDs and will provide higher accuracy than a thermocouple.

A second example would be the temperature in a reactor that ranges between 550-900°C with little vibration. Your goal is to gain accuracy within 5°C. RTDs provide consistent, accurate measurements, especially in environments with little vibration. However, do not forget the temperature range. RTDs typically should not be used above 850°C. Since the process temperature can range up to 900°C, a thermocouple would be selected. Sensors are more susceptible to failure and inaccurate measurements when used in improper temperature ranges. That is why it is critical to choose the correct sensor.

To learn more about RTDs and T/Cs, go to ***www.rosemount.com/TempGuide*** and order the **Engineer's Guide to Industrial Temperature Measurement.**

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