

High Temperature Rtd

A practical guide to high temperature rtd, covering the reader intent, the relationship to high temperature rtd, key evaluation criteria, common risks, and the information the intended project audience should confirm before taking the next step.



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In industrial process control, temperature is a fundamental variable that dictates the efficiency, safety, and quality of production cycles. While many applications operate within moderate ranges, heavy industries such as chemical processing, power generation, and metal refining often require precision measurement at elevated temperatures. The high temperature RTD (Resistance Temperature Detector) is a critical instrument in these environments, offering superior stability and accuracy compared to many alternative sensors.

This guide explores the engineering principles, selection criteria, and practical installation considerations for high temperature RTDs, providing a technical framework for engineers and procurement specialists seeking reliable thermal monitoring solutions.

| Principles of RTD Measurement

The operation of a Resistance Temperature Detector is based on a well-known physical phenomenon: the electrical resistance of a metal increases as its temperature rises. This relationship is highly predictable and repeatable, making RTDs one of the most accurate temperature sensing technologies available.

| The Temperature Coefficient of Resistance (TCR)

Most industrial RTDs utilize platinum (Pt) as the sensing element due to its chemical inertness and linear resistance-to-temperature relationship. The standard coefficient for platinum is $0.00385 \, \Omega/\Omega/^{\circ}\text{C}$. The resistance at any given temperature is typically calculated using the Callendar-Van Dusen equation, which accounts for the non-linearities at extreme ends of the temperature scale.

| Pt100 vs. Pt1000

- Pt100: The most common type, providing 100 ohms of resistance at 0°C . It is preferred for high-temperature applications because the lower resistance minimizes the impact of insulation leakage at extreme heat.

- Pt1000: Provides 1000 ohms at 0°C. While it offers higher resolution, it is more susceptible to errors in high-temperature environments where the insulation resistance of the sensor assembly might degrade.

| Construction of High Temperature RTDs

Standard RTDs are often limited to 250°C or 400°C due to the materials used in their construction, such as epoxy seals or plastic-insulated lead wires. A high temperature RTD is specifically engineered to withstand environments reaching up to 600°C, 850°C, or even higher in specialized configurations.

| Sensing Elements

1. Wire-Wound Elements: These consist of a fine platinum wire coiled around a ceramic or glass mandrel. For high-temperature use, the wire is supported in a way that allows for thermal expansion without mechanical stress, which could otherwise cause resistance shifts (drift).
2. Thin-Film Elements: These are created by depositing a thin layer of platinum onto a ceramic substrate. While traditionally limited to lower temperatures, advanced thin-film sensors are now available for high-temperature use, offering better vibration resistance and lower costs.

| Sheath and Insulation Materials

At high temperatures, the choice of sheath material is paramount. Stainless steel (316/304) is common for temperatures up to 500°C, but Inconel® 600 is often required for temperatures exceeding 600°C to prevent oxidation and maintain structural integrity. Internally, high-purity alumina (Al₂O₃) powder or ceramic insulators are used to isolate the lead wires, as standard fiberglass or Teflon would fail.

Selection Criteria for Industrial Applications

When selecting a high temperature RTD, engineers must balance accuracy requirements with the mechanical rigors of the application. The following table outlines the primary considerations for high-temperature environments.

RTD Selection Reference Table

Feature	Specification	Impact on High-Temp Performance
Accuracy Class	Class A or Class B (IEC 60751)	Class A provides tighter tolerances but may be harder to maintain at >600°C.
Wiring Configuration	3-wire or 4-wire	4-wire is essential for high accuracy to eliminate lead wire resistance errors.
Sheath Material	Inconel 600 / 310 Stainless	Prevents sensor contamination and high-temperature corrosion.
Immersion Length	Minimum 10x Sheath Diameter	Prevents "stem conduction" where heat escapes through the sheath.
Seal Type	Hermetic Ceramic Seal	Prevents moisture ingress which causes insulation resistance (IR) failure.

For comprehensive process monitoring, temperature data is often integrated with level measurement systems. For more information on integrated industrial instrumentation, you can visit the [Main Page](#) to review product options and application support.

| Wiring Configurations and Lead Wire Compensation

In high-temperature applications, the resistance of the lead wires connecting the sensor to the transmitter can change significantly as the ambient temperature around the wires fluctuates. This can introduce substantial errors if not properly compensated.

1. 2-Wire RTDs: These are rarely used in high-temperature industrial settings because they provide no way to compensate for lead wire resistance. They are only suitable for very short distances where high precision is not required.
2. 3-Wire RTDs: The industry standard. A third wire allows the bridge circuit or transmitter to measure and subtract the lead wire resistance, assuming all three wires have identical resistance.
3. 4-Wire RTDs: The most accurate configuration. It uses two wires to carry the excitation current and two wires to measure the voltage drop across the element. This completely eliminates the effect of lead wire resistance and is highly recommended for high temperature RTD installations where precision is paramount.

| Challenges and Limitations at High Temperatures

While RTDs are highly reliable, they face specific physical challenges when pushed to their thermal limits:

- Sensor Drift: Long-term exposure to high heat can cause the platinum wire to undergo physical changes or become contaminated by metal ions migrating from the sheath. This results in a gradual shift in the resistance-to-temperature calibration.
- Insulation Resistance (IR) Degradation: At high temperatures, the ceramic insulators and packing materials can become slightly conductive. This "shunting" effect allows current to leak between the leads, resulting in a lower resistance reading and a falsely low temperature measurement.

- **Mechanical Stress:** Rapid thermal cycling (heating and cooling) can cause mechanical fatigue in the sensing element due to the different expansion rates of the platinum and the ceramic support.
- **Vibration:** Wire-wound elements are more delicate than thin-film elements. In high-vibration environments, such as near large pumps or turbines, specialized ruggedized RTDs are required.

| Installation and Maintenance Best Practices

Proper installation is as critical as the sensor selection itself. Failure to follow engineering best practices can lead to premature sensor failure or inaccurate data.

| Thermowell Usage

In most high-temperature applications, the RTD should not be exposed directly to the process media. A thermowell acts as a pressure-tight barrier, protecting the sensor from high velocity, corrosive chemicals, and mechanical impact. It also allows the sensor to be replaced without shutting down the process. Ensure the RTD is spring-loaded to maintain contact with the bottom of the thermowell for optimal heat transfer.

| Immersion Depth

To avoid measurement errors caused by heat conduction along the sheath (stem conduction), the sensor must be immersed deeply enough into the process. A general rule of thumb is an immersion depth of at least 10 times the outer diameter of the protection tube.

| Maintenance and Calibration

High temperature RTDs should be calibrated periodically. Unlike thermocouples, which can be checked for "homogeneity," RTDs are typically calibrated by comparison in a dry block or salt bath. If a sensor shows significant drift or a drop in insulation resistance, it should be replaced rather than recalibrated, as these are signs of internal degradation.

| High Temperature RTD vs. Thermocouple

Engineers often choose between RTDs and thermocouples for high-heat applications. While thermocouples (Type K, N, R, S) can reach much higher temperatures (up to 1700°C), the high temperature RTD is preferred for applications up to 850°C where accuracy and stability are the primary concerns. Thermocouples are prone to "drift" over time due to wire oxidation, whereas a well-designed RTD maintains its calibration for much longer.

| Frequently Asked Questions (FAQ)

Q: What is the maximum temperature a standard RTD can measure?

A: While standard industrial RTDs often top out at 400°C to 600°C, specialized high temperature RTDs with Inconel sheaths and ceramic elements can measure up to 850°C.

Q: Why is 4-wire wiring recommended for high-temperature sensors?

A: High temperatures often mean long cable runs to reach cooler transmitter locations. 4-wire configurations eliminate the measurement error caused by the resistance of these long lead wires.

Q: Can I use a high temperature RTD in a high-vibration environment?

A: Yes, but you must specify a thin-film element or a specially supported wire-wound element. Standard wire-wound RTDs are susceptible to damage from intense vibration.

Q: How do I know if my RTD is failing due to high temperature?

A: Common signs include erratic readings, a constant "low" offset (indicating insulation breakdown), or a complete open circuit (indicating a broken sensing wire).

| Conclusion

The high temperature RTD remains a cornerstone of precision industrial measurement. By understanding the nuances of material selection, wiring configurations, and the physical limitations of platinum elements, engineers can implement robust temperature monitoring solutions that withstand the most demanding thermal environments. For those managing complex industrial sites, integrating these sensors with reliable level and flow instrumentation ensures a holistic approach to process automation. To explore a wider range of industrial measurement instruments, including radar and ultrasonic level sensors, visit the [Main Page](#) for technical specifications and expert support.