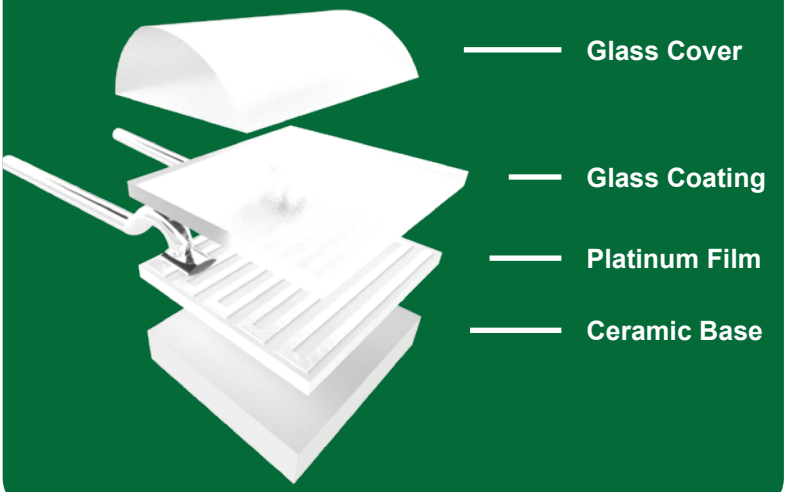
RESISTANCE TEMPERATURE DETECTORS (RTD)

What is an RTD?

An RTD (Resistance Temperature Detector) is a temperature sensor that uses electrical resistance to indicate temperature. Certain metals display a characteristic and well-defined change in electrical resistance that corresponds to a change in temperature. By measuring the resistance of a known metal, the temperature can be calculated based on known response curves. RTDs are manufactured by placing a precise amount of metal onto a ceramic base in a thin film or wound wire format. By passing a small, precise current, typically 1mA, through the RTD and measuring the corresponding resistance, the temperature can be calculated.

Elements of a Thin Film RTD



A common misconception is that RTD accuracies are a fixed percentage across the board. This is not true. The accuracy of an RTD varies with temperature. To find the accuracy of an RTD, a formula is used to calculate the accuracy at a specific temperature point. Reotemp offers platinum RTDs that conform to internationally recognized classes. For each class, a different formula is used to calculate the accuracy at the specified temperature. These standards specify the accuracy formulas for an industrial platinum RTD. For customers who require a higher accuracy than offered in the B, A or AA classes, Reotemp offers 1/10 B RTDs. 1/10 B RTDs are 10 times more accurate than class B RTDs.

Types of RTDs

RTD's are categorized into different groups based on the resistivity of the metal used inside. Most modern industrial RTD's use platinum as the resistive metal due to its inherent stability, temperature range and regularity of its temperature curve. Reotemp also offers less common RTD types such as nickel or copper to match and replace legacy and niche sensors.

Platinum RTDs are offered with various classes/accuracy tolerance values. These classes are specified in IEC 60751 and ASTM E1137. Please see the RTD Tolerance Classes table on this page for the typical platinum RTD tolerance classes.

RTD TOLERANCE CLASSES

Tolerance Class	Operating Range °C	Tolerance Range °C	Tolerance Values °C	Reotemp Code
B	-200 to +600	-200 to +600	± (0.3 + 0.005 | t |)	PX
A	-200 to +600	-30 to +300*	± (0.15 + 0.002 | t |)	PA
AA	-200 to +600	0 to +150*	± (0.1 + 0.0017 | t |)	PD
1/10 B	-200 to +600	0 to +50*	± (0.03 + 0.0005 | t |)	PE

*Class B tolerance for rest of operating range.

RTD REFERENCE INFORMATION

ACCURACY COMPARISON: CLASS A VS B		
Temperature °C	Class A RTD °C	Class B RTD °C
-190	1.25	1.25
-100	0.80	0.80
-50	0.55	0.55
0	0.15	0.30
50	0.25	0.55
100	0.35	0.80
200	0.55	1.30
300	0.75	1.80
500	2.80	2.80

Advantages of RTDs vs Thermocouples

- The primary reason RTDs are chosen over thermocouples is their **superior accuracy**. See the chart Accuracy Comparison: Thermocouple vs RTD.

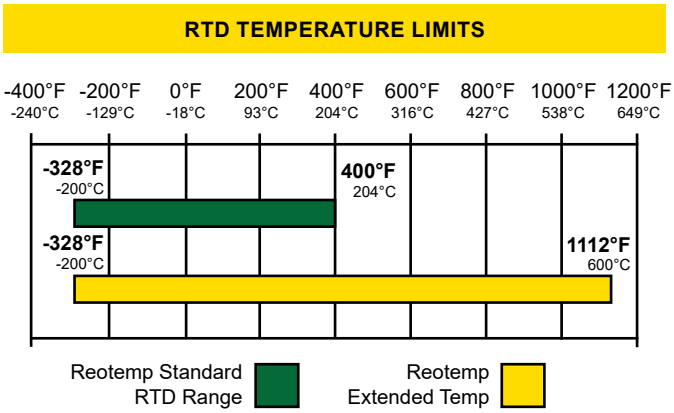
ACCURACY COMPARISON: THERMOCOUPLE VS RTD		
	Type K Thermocouple	Class B RTD
32°F (0°C)	± 3.96°F (2.2°C)	± 0.54°F (0.3°C)
392°F (200°C)	± 3.96°F (2.2°C)	± 2.34°F (1.3°C)

- RTDs offer **better stability** with less temperature drift over time as they age versus thermocouples. Less temperature drift results in a longer service life and more accurate data.
- RTDs are also a better choice for **low temperature applications** as they have much better accuracies below 0°C. At temperatures below 0°C, thermocouples are less stable and less reliable.
- RTDs offer **better repeatability**. When temperature moves from a point and then returns, RTDs return much closer to the original point.
- RTDs offer **greater interchangeability**. When replacing or swapping sensors, the match between each sensor is much closer.
- In cases where **long lead wires** are required, RTDs are often recommended. This is because thermocouples require a more expensive lead wire consisting of the same metal as the thermocouple sensor. With RTDs, only common copper hook up wire is needed.

Operating Temperature Range

Reotemp RTDs are typically offered in two versions of operating temperature ranges. The chart below shows the operating ranges of standard and extended temperature RTDs. Choose the extended temperature option when the application requires high temperature exposure.

RTD Failure Modes Explained



RTDs are extremely reliable temperature sensors. However, when they do fail, the failure modes can be typically broken down into the following categories:

Excessive Temperature

When RTDs exceed their designed temperature limits, the wire insulation materials in the stem will start to break down. This can result in electrical shorts and resistance errors. It can also create pinholes in the stem and cracks in the potting sealing the stem. When the stem integrity is breached, moisture can then get in and cause resistance errors.

Corrosion

Corrosion will often result in pinholes and pits in the stem. Once the stem is no longer sealed, moisture and the process can penetrate the stem causing resistance errors and electrical shorts. Some solutions to corrosion include thermowells or Teflon coated stems.

Extreme Vibration

Extreme vibration fatigues and strains wires and welded connections inside the sensor assembly. This can result in resistance errors as well as connection breaks. Reotemp's solution to this failure mode is the unique Hi-Vibe™ option for vibration applications.

RTD REFERENCE INFORMATION

User Abuse

Some examples of user abuse include wires shorted out from being twisted together or corrosive media being allowed into the RTD assembly head.

Wire Configurations of RTDs

RTDs can be built in 2-wire, 3-wire and 4-wire configurations. 2-wire configurations are the most basic, and offer no lead wire compensation. This means that the resistance of the lead wire is added to the resistance of the RTD element which makes the measured temperature appear higher than the actual temperature. While the influence of lead wire resistance is minimal for short runs, longer lead wire results in a higher discrepancy.

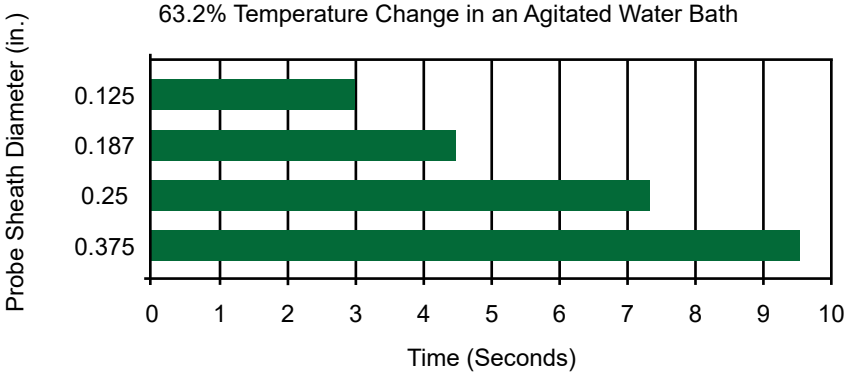
A 3-wire configuration uses the third wire to sample lead wire resistance and subtract it from the measurement circuit. This is the most common configuration for industrial applications and provides adequate compensation for lead wire resistance.

A 4-wire configuration fully isolates the resistance of the RTD element from the resistance of the lead wire and is recommended for applications requiring the highest accuracy.

RTD Response Time

The diameter of the RTD probe will affect the response time of an RTD, as shown in the RTD Typical Response Times chart on this page. If response time is critical, consider using the smallest diameter probe which still meets the application requirements.

RTD TYPICAL RESPONSE TIMES



HI-ACCURACY AND HI-VIBE

REOTEMP HI-ACCURACY™

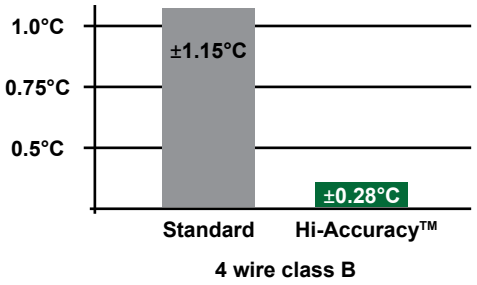
Hi-Accuracy™

When you need the highest possible accuracy…

Hi-Accuracy™ is an optional feature on many Reotemp RTD sensors. Reotemp uses specialized fixed point calibration cells to determine more precise coefficients for the specific sensor in your order. You will input these values into your transmitter to replace the generic values. Once the sensor-specific coefficients are entered, your sensor will typically be 5 times more accurate! **Add this feature by selecting –AC in the options section of the RTD configurator.**

The graph below shows the typical accuracy improvement for a temperature sensor system. Without the Hi-Accuracy option the temperature reading could potentially be off 1.15°C from the actual process value vs 0.28°C with Reotemp's hi-accuracy option.

TOTAL SYSTEM ACCURACY COMPARISON AT 150°C



Sensor with Transmitter Comparison at 150°C	
Standard Sensor	
Sensor Assembly with Standard 4-wire Class B RTD	± 1.05°C
Reotemp Model W Transmitter	± 0.10°C
Total System	± 1.15°C
Sensor with Hi-Accuracy™ Option	
Assembly with Standard 4-wire Class B RTD	± 0.18°C
Reotemp Model W Transmitter	± 0.10°C
Total System	± 0.28°C

REOTEMP HI-VIBE™

Hi-Vibe™

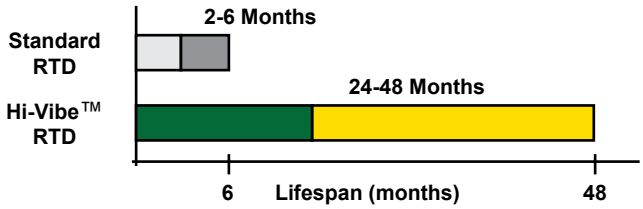
Hi-Vibe™ is an optional feature available on many Reotemp RTD sensors. Although thin film RTDs are very robust, vibration is a common cause of premature failure or drift in an RTD sensor. Reotemp's Hi-Vibe construction is a proprietary design that reinforces welds and other weak points around the RTD to better withstand shock due to vibration. Hi-Vibe has been proven to significantly improve lifespan and help to maintain accuracy in high vibration environments.

Case Study: Turbine Test Cells

Customer: Major Turbine Manufacturer in Western US

Problem: Sensors on turbine test cells were failing after a short period of time (2-6 months) causing maintenance downtime and excessive replacement costs. The RTDs were found to be failing due to the shock and resonance from the high frequency vibrations in turbine operation.

Solution: After several rounds of testing, Reotemp developed a stronger Hi-Vibe RTD construction that could better withstand the extremely harsh turbine test cell environment. The turbine manufacturer tested the new design for over a year with excellent results as shown in the chart below. Ongoing testing has shown the lifespan to be improved by a factor of 4-10 times versus the standard sensor. Ultimately, this turbine manufacturer switched all of their turbine RTD sensor requirements over to this Reotemp Hi-Vibe design for improved performance.



By reinforcing potential weak points in a standard RTD construction, the Hi-Vibe feature dramatically extends the life of a sensor under high vibration conditions. If your application is subject to vibration, the Hi-Vibe design is an excellent option to consider.

Benefits:

- Design minimizes failure modes of vibration
- Increases the life of your RTD up to 10x
- Reduces frequent replacement cost due to vibration failure
- Allows usage of RTDs in applications previously restricted to thermocouples
- Improves process efficiency with higher accuracy RTDs

How to Order This Feature:
In the options section of the RTD part builder, use the **-VB** code.

WIRE LENGTH GUIDE

Actual maximum lead wire length is dictated by total loop resistance and the presence of electrical noise. Allowable loop resistance is dictated by the equipment used to measure the sensor's signal. The tables below have been generated using assumptions of allowable loop resistance. Final determination of suitability rests with the customer. Green zones indicate estimated lead wire lengths that will allow the temperature sensor to still function properly with limited accuracy loss. The exact accuracy loss is dependent on a number of application specific factors.

	Assembly is expected to function properly with limited accuracy loss. The exact accuracy loss is dependent on a number of application specific factors.
SL	Assembly is likely to have significant accuracy loss and may not function properly.
X	Assembly is not recommended. Consider a 4-20mA transmitter or thicker wire gauge.

Sensor Type	Wire Size (AWG)	0-50 ft.	51-100 ft.	101-150 ft.	151-200 ft.	200-300 ft.	300-500 ft.	500-1000 ft.	1000 ft. +
3 or 4 Wire RTD*	18							SL	X
	20						SL	X	X
	22					SL	X	X	X
	24				SL	X	X	X	X
	26			SL	X	X	X	X	X
	28		SL	X	X	X	X	X	X
	30	SL	X	X	X	X	X	X	X
		0-50 ft.	51-100 ft.	101-150 ft.	151-200 ft.	200-300 ft.	300-500 ft.	500-1000 ft.	1000 ft. +
Type K	18					SL	X	X	X
	20				SL	X	X	X	X
	24		SL	X	X	X	X	X	X
	26	SL	X	X	X	X	X	X	X
	30	SL	X	X	X	X	X	X	X
		0-50 ft.	51-100 ft.	101-150 ft.	151-200 ft.	200-300 ft.	300-500 ft.	500-1000 ft.	1000 ft. +
Type J	18						SL		
	20					SL	X		
	24			SL	X	X	X		
	26		SL	X	X	X	X		
	30	SL	X	X	X	X	X		
		0-50 ft.	51-100 ft.	101-150 ft.	151-200 ft.	200-300 ft.	300-500 ft.	500-1000 ft.	1000 ft. +
Type T	18							SL	
	20						SL	X	
	24			SL	X	X	X	X	
	26		SL	X	X	X	X	X	
	30	SL	X	X	X	X	X	X	
		0-50 ft.	51-100 ft.	101-150 ft.	151-200 ft.	200-300 ft.	300-500 ft.	500-1000 ft.	1000 ft. +
Type E	18					SL			
	20			SL	X	X			
	24		SL	X	X	X			
	26	SL	X	X	X	X			
	30	SL	X	X	X	X			
		0-50 ft.	51-100 ft.	101-150 ft.	151-200 ft.	200-300 ft.	300-500 ft.	500-1000 ft	1000 ft. +
4-20 mA Transmitters	18								
	20								
	22								
	24								
	26								
	28								
	30							SL	X

*4 wire RTDs are recommended for minimum accuracy loss.

HEAD STYLES

All head styles are IP65 or greater. Additional head styles available, contact customer service for more information.

Head	Code	Description	NEMA Rating	IP Rating	FM APPROVED	CSA C US	Ex	Display	STD Conduit	Material
	A	Cast Iron Black	4	65					3/4"	Cast Iron
	B	Cast Aluminum	4X	68					3/4"	Cast Aluminium
	E	Explosion Proof Aluminum	4X	68	✓	✓			3/4"	Cast Aluminium
	I	Blue Epoxy Aluminum	4X	68					3/4"	Cast Aluminium
	S	Polypropylene White	4	65					3/4"	Polypropylene
	W	Explosion Proof Field HART Transmitter	4X	68	✓	✓	✓	✓	1/2"	Cast Aluminium
	Z	Z-Temp™ Explosion Proof Aluminum	4X	66	✓	✓	✓	✓	1/2"	Cast Aluminium
	C	Polypropylene Black	4	65					3/4"	Polypropylene
	G	316SS	4X	65					3/4"	316SS
	H	Aluminum Flip Top	4	65					3/4"	Cast Aluminium
	J	Explosion Proof 316SS	4X	65	✓	✓			3/4"	316SS
	T	ATEX Explosion Proof Aluminum	4X	68	✓	✓	✓		1/2"	Cast Aluminium
	L	Explosion Proof Epoxy Coated Aluminium	4X	68	✓	✓			3/4"	Cast Aluminium
	D	Mini Cast Aluminum	4	65					3/4"	Cast Aluminium
	K	Polished 316SS Knurl	4X	65					1/2"	316SS
	P	DIN Black Polypropylene	4	65					3/4"	Polypropylene
	U	Hi-dome Aluminum Fliptop	4	65					3/4"	Cast Aluminium
	V	Ball-dome Aluminum Fliptop	4	65					3/4"	Cast Aluminium

HAZARDOUS LOCATION CERTIFIED THERMOCOUPLE & RTD OPTIONS

		Thermocouple	RTD
CERTIFICATION OPTIONS			
-R1	1 Point Calibration Certification, Reotemp Chooses	✓	✓
-R3	3 Point Calibration Certification, Reotemp Chooses	✓	✓
-C1	1 Point Calibration Certification, Customer Chooses	✓	✓
-C3	3 Point Calibration Certification, Customer Chooses	✓	✓
-CC	Certificate of Conformance	✓	✓
-CS	NIST Calibration Sticker (No Logged Points)	✓	✓
OTHER OPTIONS			
-VB	Hi-Vibration	N/A	✓
-AC	Hi-Accuracy	N/A	✓
-PS	Pointed Stem	✓	✓
-HT	Heat Transfer Compound (2 oz)	✓	✓
TAG OPTION			
-TS	Stainless Steel Tag (1-10 Characters)	✓	
-TM	Stainless Steel Tag (11-80 Characters)	✓	
-TP	Paper Tag	✓	

✓	Indicates that the option is available with this model.
N/A	Indicates the option is not available with this model.
STD	Indicates standard options with no additional cost.

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	W	Explosion Proof Field HART Transmitter	4X	68	✓	✓	✓	✓	1/2"	Cast Aluminium
	Z	Z-Temp™ Explosion Proof Aluminum	4X	66	✓	✓	✓	✓	1/2"	Cast Aluminium
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	T	ATEX Explosion Proof Aluminum	4X	68	✓	✓	✓		1/2"	Cast Aluminium
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-C1	1 Point Calibration Certification, Customer Chooses	✓	✓
-C3	3 Point Calibration Certification, Customer Chooses	✓	✓
-CC	Certificate of Conformance	✓	✓
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-VB	Hi-Vibration	N/A	✓
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-PS	Pointed Stem	✓	✓
-HT	Heat Transfer Compound (2 oz)	✓	✓
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-TP	Paper Tag	✓	

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