



# Resistance Sensors

## Resistance Temperature Detectors (RTD) Introduction

### Principle

Resistance Temperature Detectors (RTDs) are based on the principle that coils of certain metals change in resistance as they change in temperature.

This is particularly true of platinum, which is used in the most common types of RTD.

By measuring this change in resistance, you can accurately measure temperature.

### Advantages

- Very accurate and stable
- Converter costs are lower than for thermocouples

### Disadvantages

- Sensor cost is high compared to thermocouples
- The sensor tip is more fragile and susceptible to damage from vibration
- Not suitable for extremely low or very high temperatures
- Slow response when compared to thermocouples

### Styles

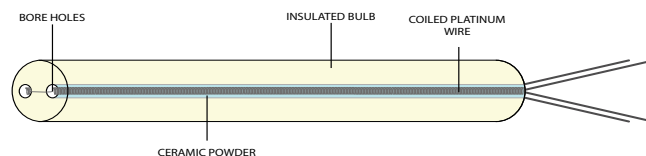
There are three main types of RTD, the most common being the coiled element.

Coiled elements are built from tiny platinum coils that are placed within two holes drilled into a insulating material (such as ceramic). The holes are then filled with a fine grain ceramic powder, which allows the temperature to reach the coils but at the same time gives them room to expand and contract.

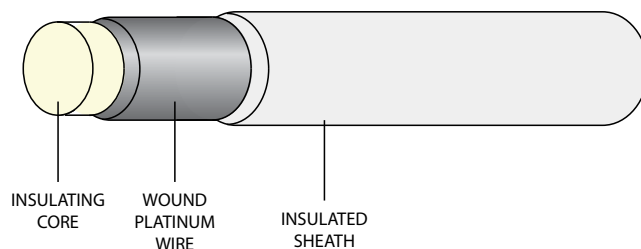
This gives a sensor with the highest accuracy, but the least protection against vibration or damage.

Wire-Wound sensors instead have a solid insulating core with the wire wrapped around it. It is then normally coated in an additional insulating layer. This gives a significantly stronger sensor, but the fact that the wire can not expand and contract freely lowers your accuracy.

Thin-film sensors are far more robust, not using coils at all but instead using a thin layer of platinum placed on an insulator. While providing excellent vibration and impact resistance, they lack accuracy.



A drawing of a coiled RTD element



A wire-wound RTD element



# Resistance Sensors

Sensor Types

## Number Of Wires

Because you are measuring your temperature with resistance, your cable becomes a problem.

The longer and thinner your RTD cabling is, the more resistance it creates. Since your signal is based on resistance, this has the effect of making your sensor less accurate by falsely elevating your signal.

You can avoid these problems by using three or four wire sensors.

In a three wire sensor, two red wires are attached to the same side of the sensor right before the bulb. This means that by measuring the resistance across both red wires, you know how much total resistance there is in your cabling.

This way, you can eliminate the error.

Four wire sensors are also available but are a lot less common. They are mainly used in laboratory applications where they need to ensure resistance isn't different in the two sides of the cable, or in situations where for some reason one side of the cable is longer than the other.

## RTD Base Resistance

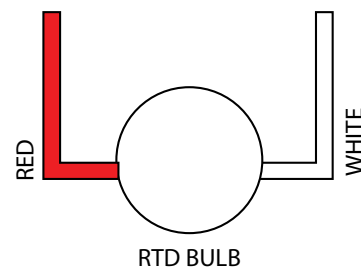
One other way of eliminating the noise caused by your cabling is using an RTD that creates more resistance per degree. Your most common RTD is a PT100. The PT indicates that it is a platinum sensor, the 100 tells you that it has a resistance of 100 Ohms at 0 degrees C.

Using a PT1000 instead gives you 1000 Ohms at 0 degrees, and gives 10x the change in resistance for every degree of temperature change.

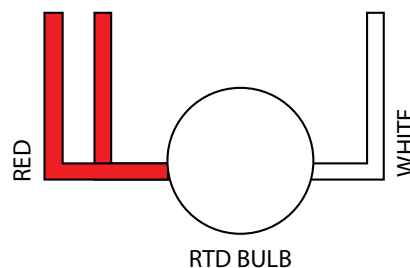
There are other options as well, such as NTC sensors. These have very high levels of resistance, but are only suitable for very narrow temperature ranges and work in the opposite direction - an increase in temperature results in a drop of resistance.

## RTD Class

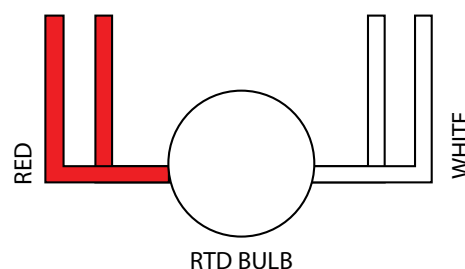
Most normal RTD bulbs are Class B, meaning they are made accurate to 0.12% at 0 degrees. Class A bulbs are accurate to 0.06% at 0 degrees and are used on the most demanding applications.



2 WIRE RTD



3 WIRE RTD



4 WIRE RTD

### Designing a Sensor

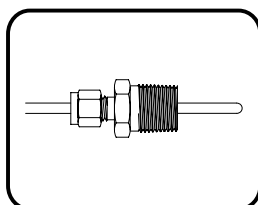
Many people think they can simply order an off-the-shelf 'RTD' and have it suit their requirements. In almost all cases, this is incorrect. While there are some common designs, the vast majority of temperature sensors are custom made to suit specific applications.

We can only offer a rough guide to what is possible - there are still countless options that we won't cover here.

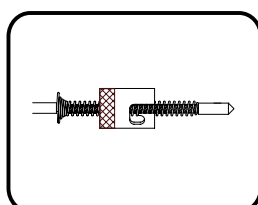
However, each sensor is made up of three or more sections.

### The Tip

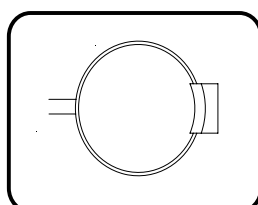
The tip of the sensor is the part that houses your junction or RTD bulb and is subjected to the most extreme conditions. You also need to consider how your sensor will actually be attached to the item you want to monitor.



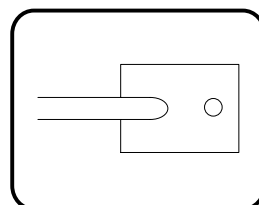
A stainless tube and sliding compression fitting to fit this sensor into a tapping point



A bayonet fitting allows you to connect and disconnect quickly and easily



A pipe-mounted sensor clamps straight onto your pipework



A surface sensor can be attached with adhesives

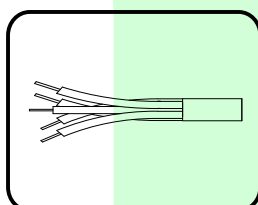
### The Middle

The middle of your sensor can be made up of any number of lengths of tube, wire, cable or conduit. You can include bulkhead fittings to allow you to pass through walls, brackets to clamp onto surfaces or different grades of protection that give you heat and impact resistance.

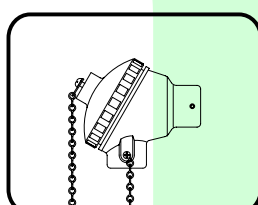
When it comes to cables, PVC is extremely inexpensive, PFA gives your sensor resistance to aggressive chemicals, fiberglass braid can tolerate high temperatures and stainless steel armor gives you extremely high levels of mechanical protection. There are also many other materials and wire types you can use for different applications.

### The End

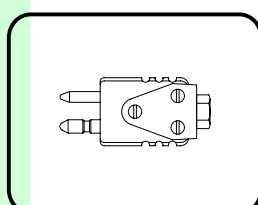
There are a number of options for how your sensor ends and plugs into your transmitters or other devices.



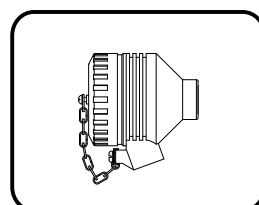
Bare or lugged wires allow you to connect to your converter directly



A terminal head houses either screw terminals or a small head-mounted transmitter



Plugs allow you to easily connect devices in and out



Ex D heads allow sensors to be installed in hazardous locations