

## 3-Wire vs. 4-Wire Technical Brief

### **Overview:**

The electronic device you're using to interpret the RTD's resistance is usually the deciding factor here. It may utilize 3-wire RTDs only, or offer both 3- and 4-wire.

3-wire is the industry workhorse for good reason. It provides solid accuracy that typically exceeds industrial needs and is the most economical with respect to simplified electronics and less wire (more on this below).

4-wire will give you better accuracy, especially with long wire runs.

A little more if you're curious:

It's all about focus. Your device wants only the sensor's resistance – not the resistance of the leadwires that connect it to the device.

The resistance of the sensor is what's used to find the temperature. Your device is designed to track the electrical characteristics of the particular metal of the high-accuracy RTD sensor as it reacts to temperature variations. Copper hookup wire (or nickel, etc.), each have their own characteristics differing widely from the sensor (resistance change with temperature, linearity, base resistance, etc.). So the challenge is to only "see" the resistance of the sensor and to "ignore" the resistance of the leadwires that are attached to the sensor.

### **2-wire (not ideal):**

Right off the bat let's show why 2-wire is not listed above, since it is the reason for the evolution of the 3- and 4-wire versions. If you simply add a 6" length of 24awg stranded copper hookup wire to each side of a 100 ohm .00385 alpha platinum resistor element (let's use this since it's the de facto standard), you now have turned it into a kind of cross-breed. Now, the inaccurate lead wires (functioning as a sensor, mind you) and the highly accurate Pt sensor element are now one sensing entity. Keep in mind, the lead wires go all the way down the inside of the stem its tip. Our 6" example here could be a 3" long probe with 3" leads out the probe. We run across a 2-wire application every now and then, but this means the accuracies required are very liberal (more like suggestions rather than specs).

### **3-wire (standard, very good):**

If you add a third wire to the mix, your device has a circuit that first measures the resistance between wires 2 and 1 and writes down that number, measures the resistance between wire 2 and 3, and then subtracts that number from the first one. Viola, what's left is the resistance of the element sans the lead wires. We make sure your lead wires are all the same length and gauge to optimize this type circuit.



**4-wire (best, very good):**

Then why use 4-wire? This configuration knows more than just the math. The 4<sup>th</sup> wire allows a 4-wire bridge circuit: it feeds an even flow of juice into wires 1 and 4, and tracks the action the sensor “sees” between wires 2 and 3. This type of bridge circuit (known as a “true” bridge) is able to eliminate any lead wire issues. Uneven lead lengths among the 4 wires (especially with long wire runs) – no problem! Mixed wire gauges – no problem! The electrical contacts and external lead wire conductors oxidizing, changing their resistances – no problem! Dissimilar ambient activity among the lead wires – no problem! (All these degrade the accuracy of a 3-wire setup since there would be a big enough remainder left over after the subtraction.)

Moral to the story: if your device has the 4-wire option, go ahead and use it! If you’re deciding on a transmitter for instance, maybe the little extra insurance that the 4<sup>th</sup> wire brings is worth it.