



# **Instrumentation and Control: Temperature, Pressure, Flow, Level and Position Indication**

**An Online Continuing Education Course for Engineers**

**Course Number: IC-4004**

**Credit: 4 Hours / 4 PDH / 4 CPD**

# Instrumentation and Control: Temperature, Pressure, Flow, Level and Position Indicators

## INTRODUCTION

The five sections of this course discuss the following aspects of instrumentation and control systems: temperature, pressure, flow, level, and position indication. The course describes the construction, operation, and failure modes for various types of detectors, indicators, and control circuits, and thus provides fundamental knowledge of basic system and equipment operations.

## 1. RESISTANCE TEMPERATURE DETECTORS (RTDs)

*The resistance of certain metals will change as temperature changes. This characteristic is the basis for the operation of an RTD.*

### Temperature

The hotness or coldness of a piece of plastic, wood, metal, or other material depends upon the molecular activity of the material. Kinetic energy is a measure of the activity of the atoms which make up the molecules of any material. Therefore, temperature is a measure of the kinetic energy of the material in question.

Whether you want to know the temperature of the surrounding air, the water cooling a car's engine, or the components of a facility, you must have some means to measure the kinetic energy of the material. Most temperature measuring devices use the energy of the material or system they are monitoring to raise (or lower) the kinetic energy of the device. A normal household thermometer is one example. The mercury, or other liquid, in the bulb of the thermometer expands as its kinetic energy is raised. By observing how far the liquid rises in the tube, you can tell the temperature of the measured object.

Because temperature is one of the most important parameters of a material, many instruments have been developed to measure it. One type of detector used is the resistance temperature

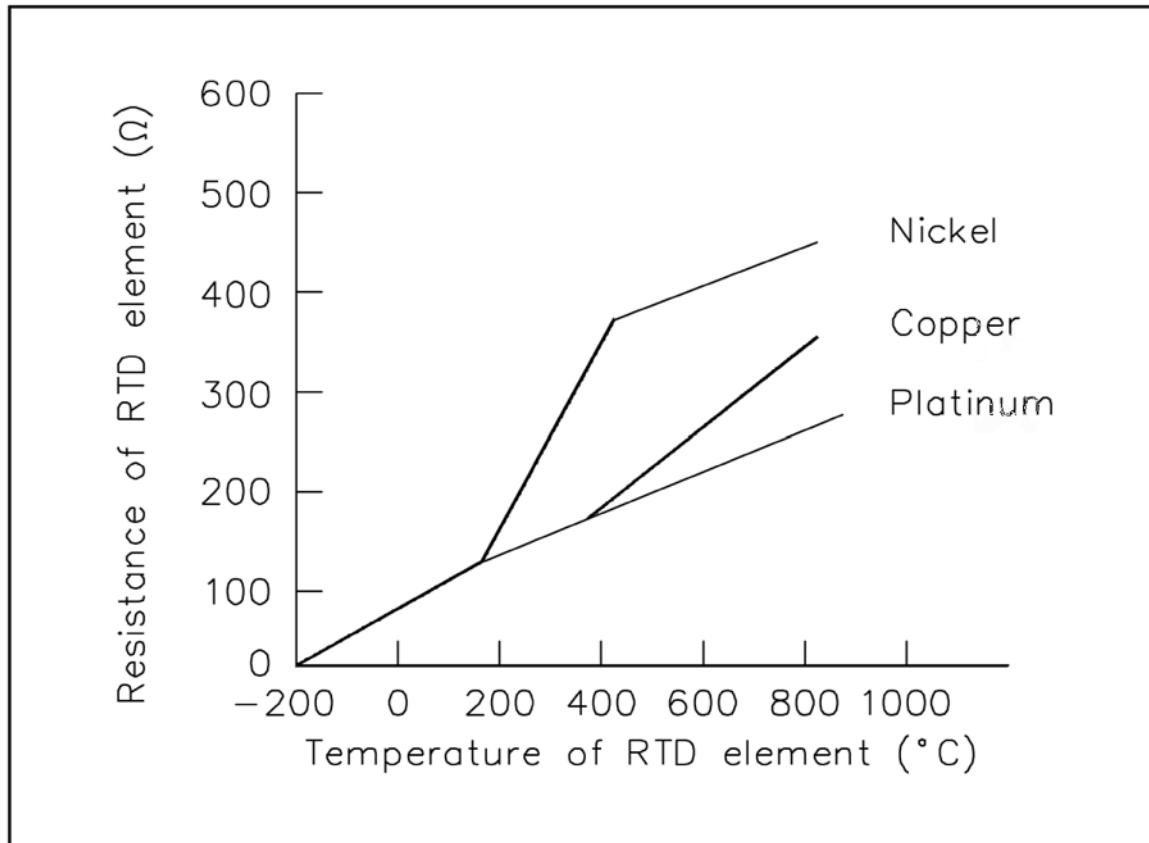
detector (RTD). The RTD is used at many facilities to measure temperatures of the process or materials being monitored.

### **RTD Construction**

The RTD incorporates pure metals or certain alloys that increase in resistance as temperature increases and, conversely, decrease in resistance as temperature decreases. RTDs act somewhat like an electrical transducer, converting changes in temperature to voltage signals by the measurement of resistance. The metals that are best suited for use as RTD sensors are pure, of uniform quality, stable within a given range of temperature, and able to give reproducible resistance-temperature readings. Only a few metals have the properties necessary for use in RTD elements.

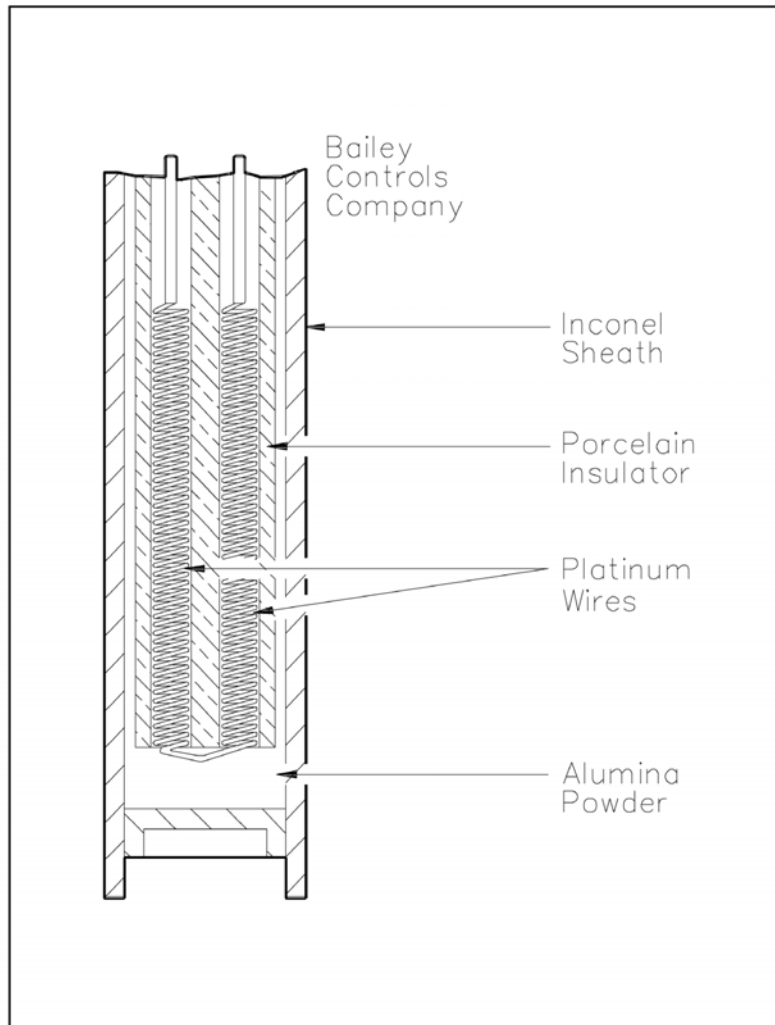
RTD elements are normally constructed of platinum, copper, or nickel. These metals are best suited for RTD applications because of their linear resistance-temperature characteristics (as shown in Figure 1), their high coefficient of resistance, and their ability to withstand repeated temperature cycles.

The coefficient of resistance is the change in resistance per degree change in temperature, usually expressed as a percentage per degree of temperature. The material used must be capable of being drawn into fine wire so that the element can be easily constructed.



**Figure 1. Electrical Resistance-Temperature Curves**

RTD elements are usually long, spring-like wires surrounded by an insulator and enclosed in a sheath of metal. Figure 2 shows the internal construction of an RTD.



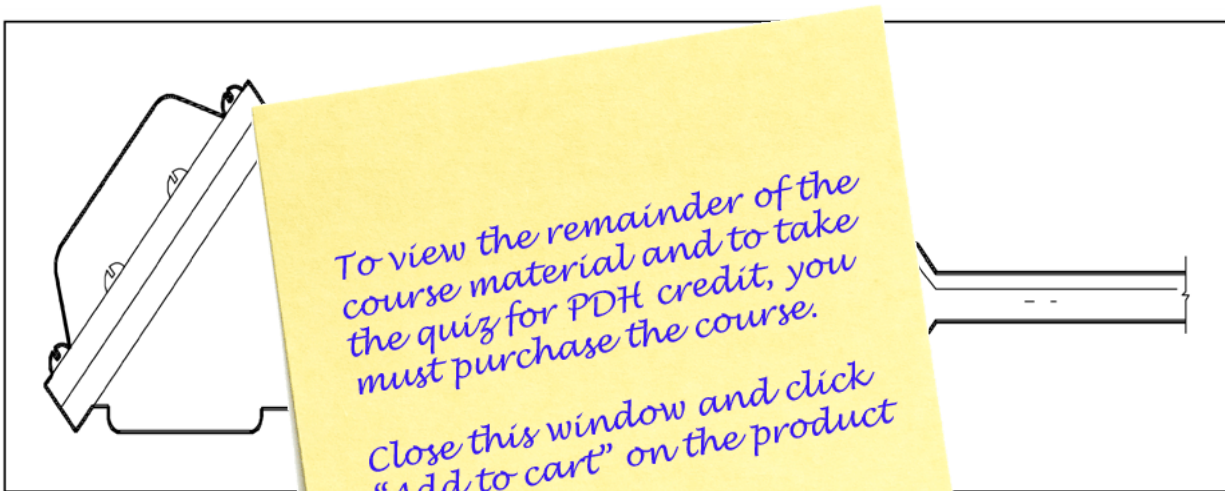
**Figure 2. Internal Construction of a Typical RTD**

This particular design has a platinum element that is surrounded by a porcelain insulator. The insulator prevents a short circuit between the wire and the metal sheath.

Inconel, a nickel-iron-chromium alloy, is normally used in manufacturing the RTD sheath because of its inherent corrosion resistance. When placed in a liquid or gas medium, the Inconel sheath quickly reaches the temperature of the medium. The change in temperature will cause the platinum wire to heat or cool, resulting in a proportional change in resistance.

This change in resistance is then measured by a precision resistance measuring device that is calibrated to give the proper temperature reading. This device is normally a bridge circuit, which will be covered in detail later in this text.

Figure 3 shows an RTD protective well and terminal head. The well protects the RTD from damage by the gas or liquid being measured. Protecting wells are normally made of stainless steel, carbon steel, Inconel, or cast iron, and they are used for temperatures up to 1100°C.



### RTD Summary

- The resistance of an RTD varies directly with temperature:
  - As temperature increases, resistance increases.
  - As temperature decreases, resistance decreases.
- RTDs are constructed using a fine, pure, metallic, spring-like wire surrounded by an insulator and enclosed in a metal sheath.
- A change in temperature will cause an RTD to heat or cool, producing a proportional change in resistance. The change in resistance is measured by a precision device that is calibrated to give the proper temperature reading.