

## BASIC THERMOCOUPLES

In 1999, The Okonite Company made a major commitment to establish a complete Instrumentation and Thermocouple Extension Product offering. This issue of "Technical News" features an explanation of a basic thermocouple and the requirements of a Thermocouple Extension Cable.

### What is a thermocouple?

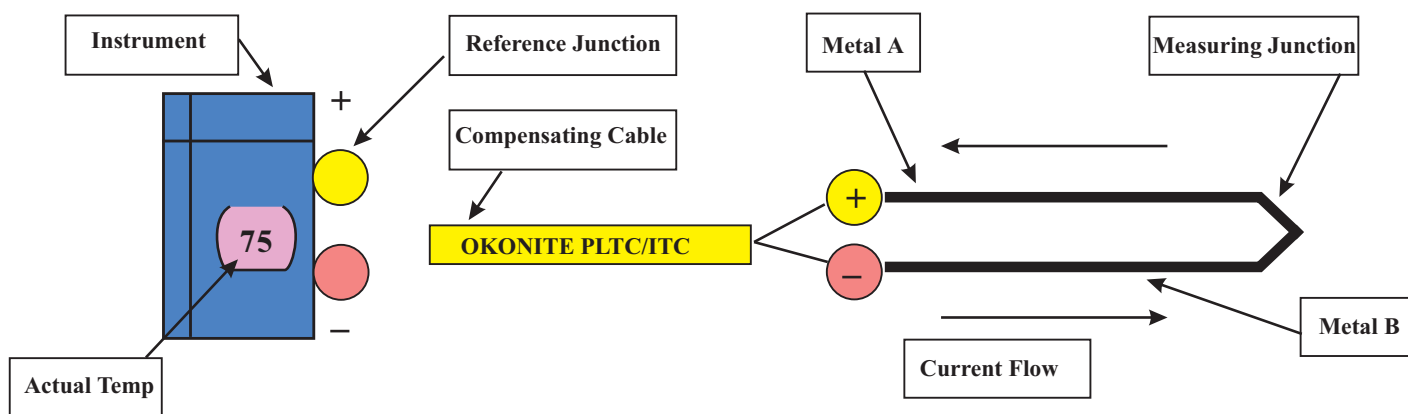
A thermocouple is a commonly used type of sensor that is used to measure temperature. Thermocouples are popular in industrial control applications because of their relatively low cost and wide measurement ranges. In particular, thermocouples excel at measuring high temperatures where other common sensor types cannot function.

Thermocouples are fabricated from two electrical conductors made of two different metal alloys. The conductors are typically built into a cable having a heat-resistant sheath, often with an integral shield conductor. At one end of the cable, the two conductors are electrically shorted together by crimping, welding, etc. This end of the thermocouple (the *hot junction*) is thermally attached to the object to be measured. The other end (*cold junction*) is sometimes called the (*reference junction*) is connected to a measurement system. The objective is to determine the temperature near the **HOT JUNCTION**.

Thermocouples generate an open-circuit voltage, called the (*Seebeck*) voltage, that is proportional to the temperature difference between the *hot* and *reference* junctions:

$$V_s = V (t_{hot} - T_{ref})$$

Since thermocouple voltage is a function of the temperature *difference* between junctions, it is necessary to know both voltage and reference junction temperature in order to determine the temperature at the hot junction. Consequently, a thermocouple measurement system must either measure the reference junction temperature or control it to maintain it at a fixed, known temperature.



## Definitions Relevant to Thermocouple Wires:

- **ANSI** American National Standards Institute
- **Compensating Alloys** Alloys used to connect thermocouples to instrumentation. These alloys are selected to have similar thermal electric properties as the thermocouple alloys.
- **Emf:** The electric potential difference, which produces or tends to produce an electric current (Electromotive force).
- **Extension Grade** A pair of wires having such a temperature/emf characteristics relative to the thermocouple with which the wires are intended to be used that, when properly connected to the thermocouple, the reference junction is transferred to the other end of the wires.
- **Limits of Error** A tolerance band for the electric response of thermocouple wire expressed in degrees or percentage as defined by ANSI specification MC-96.1.

## Notes:

1. The limits of error for each type thermocouple apply over the temperature range for which the wire size in question is recommended.
2. Limits of error apply to thermocouples as supplied by the manufacturer. The calibration of a thermocouple may change during use.
  - **Thermoelement** One of the two dissimilar electrical conductors comprising a thermocouple.
  - **Exposed Junction** The thermocouple junction or measuring point is exposed without any protection assembly or tube. Exposed junction thermocouples due to their design, offer the user the fastest response time.
  - **Immersion Length** The portion of the thermocouple, which is subject to the temperature which, is being measured.
  - **Protection Tube** A tube like assembly in which the thermocouple is installed in order to protect the element from harsh environments.
  - **RTD** Abbreviation for Resistance Temperature Detector. It is a sensor, which operates on the principle that the resistance increases with an increase in temperature at a specific rate. Commonly manufactured using a platinum resistance element. More accurate and more linear than most thermocouples and generally much more costly and slower responding.
  - **Thermowell** A threaded or flanged closed end tube, which is mounted directly to the process or vessel, designed to protect the thermocouple from the process surroundings.

## Summary

Thermocouples are temperature sensors suitable for use with any make of instrument designed or programmed for use with the same type thermocouple. Thermocouples are based on the principle that when two dissimilar metals are joined a predictable voltage will be generated that relates to the difference in temperature between the measuring junction and the reference junction. When a replacement thermocouple is required, it is of the utmost importance that the type of thermocouple used in the replacement matches that of the measuring instrument and cable.

**Wire Size of Thermocouple:** Selecting the wire size used in the thermocouple sensor depends upon the application. Generally, when longer life is required for the higher temperatures, the larger size wires should be chosen. When sensitivity is the prime concern, the smaller sizes should be used.

**Length of Thermocouple Probe:** Since the effect of conduction of heat from the hot end of the thermocouple must be minimized, the thermocouple probe must have sufficient length. Unless there is sufficient immersion, readings will be low.

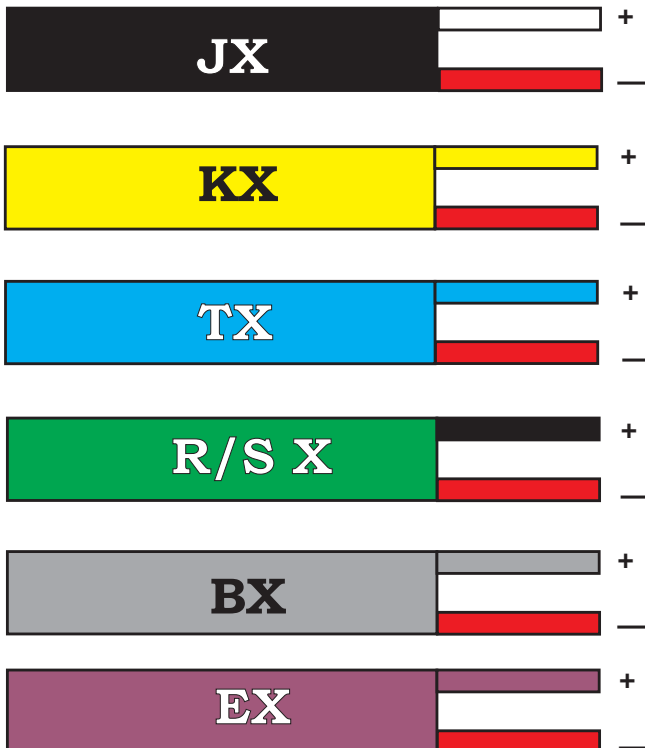
## THERMOCOUPLE TYPES

Thermocouple Type	Materials	Temperature Range
<b>B</b>	Platinum 30% Rhodium (+) Platinum 6% Rhodium(-)	2500 - 3100 F 1370 - 1700 C
<b>C</b>	W5Re Tungsten 5% Rhenium (+) W26Re Tungsten 26% Rhenium(-)	3000 - 4200 F 1650 - 2315 C
<b>E</b>	Chromel (+) Constantan (-)	200 - 165 F 95 - 900 C
<b>J</b>	Iron (+) Constantan (-)	200 - 1400 F 95 - 760 C
<b>K</b>	Chromel (+) Alumel (-)	200 - 2300 F 95 - 1260 C
<b>N</b>	Nicrosil (+) Nisil (-)	1200 -2300 F 650 - 1260 C
<b>R</b>	Platinum 13% Rhodium (+) Platinum (-)	1600 - 2640 F 870 - 1450 C
<b>S</b>	Platinum 10% Rhodium (+) Platinum	1800 - 2640 F 980 - 1450 C
<b>T</b>	Copper (+) Constantan (-)	-330 - 660 F -200 - 350 C

### Thermocouple Color Codes

Thermocouple wiring is colored coded by thermocouple types. Different countries utilize different color-coding. Jacket coloring is sometimes a colored stripe instead of a solid color as shown.

#### United States ASTM:



#### British BS1843

