

# Introduction to Thermocouples and Thermocouple Assemblies

## What is a thermocouple?

A thermocouple is a temperature sensor consisting of two dissimilar metal wires, joined at one end, and connected to a thermocouple thermometer or other thermocouple-capable device at the other end. When properly configured, thermocouples can provide temperature measurements over wide range of temperatures.

## What are the different thermocouple types?

Thermocouples are available in different combinations of metals or "calibrations". The most common are the "Base Metal" thermocouples known as Types J, K, T, E and N. There are also some special thermocouple types known as Noble Metal thermocouples, these are

Types R, S and B. The highest temperature thermocouple types are the Refractory Type thermocouples which include types C, G and D.

## How do I choose a thermocouple type?

Thermocouples are typically selected based on the following conditions:

- Temperature range
- Accuracy
- Process Compatibility (Chemical and Mechanical)
- Instrument Compatibility

## How do I know which junction type to choose?

Sheathed thermocouple types are available in three junction styles, grounded, ungrounded and exposed.

| Room Temperature Insulation Resistance |                        |                           |
|--|------------------------|---------------------------|
| Nominal Sheath mm (in)                 | Applied DC Voltage Min | Insulation Resistance Min |
| <0.80 (0.03)                           | 50 V                   | 100 MΩ                    |
| 0.80 to 1.5 (0.030 to 0.059)           | 50 V                   | 500 MΩ                    |
| >1.5 (0.059)                           | 500 V                  | 1000 MΩ                   |

(Place the existing grounded, ungrounded and exposed junction diagrams and text here, add insulation resistance table within the ungrounded section)

## What is response time?

Response time, also known as the sensor time constant, is the time required for a sensor to respond to a step change in temperature. This is normally defined under a set of conditions such as "the 63.2% response in water flowing at 3 feet per second". The 63.2% value (also known as the primary time constant) is the most common, but 50% and 90% values may also be used. The response time is a comparison measure of how quickly a sensor will indicate a change in temperature conditions, and is usually a component in determining a system response time. See Page Z-52 for typical thermocouple response times.

## Operating Atmosphere—Typical Sheath Materials

| Material                  | Maximum Temperature | Application Atmosphere |          |           |           |
|---------------------------|---------------------|------------------------|----------|-----------|-----------|
|                           |                     | Oxidizing              | Hydrogen | Vacuum    | Inert     |
| 304, 310, 316, and 321 SS | 900°C (1650°F)      | Very Good              | Good     | Very Good | Very Good |
| Inconel® 600              | 1150°C (2100°F)     | Very Good              | Good     | Very Good | Very Good |
| Super OMEGA CLAD® XL      | 1335°C (2440°F)     | Excellent              | Good     | Very Good | Very Good |
| Platinum-Rhodium Alloy    | 1650°C (3000°F)     | Very Good              | Poor     | Poor      | Poor      |
| Molybdenum                | 2200°C (4000°F)     | Not Rec.               | Fair     | Good      | Fair      |
| Tantalum                  | 2300°C (4200°F)     | Not Rec.               | Not Rec. | Good      | Not Rec.  |

## OMEGA CLAD® Specifications

**Diameters:** Standard diameters: 0.25 mm (0.010"), 0.5 mm (0.020"), 0.75 mm (0.032"), 1 mm (0.040"), 1.5 mm (1/16"), 3 mm (1/8"), 4.5 mm (3/16"), and 6 mm (1/4"), 8 mm (0.313") and 9.5 mm (0.375").

**Length:** Standard OMEGA® thermocouples have 300 mm (12") immersion lengths. Other lengths are available.

**Sheaths:** 304 SS and Inconel® are standard. Other sheath materials are available; call for price and availability.

**Insulation:** High-purity magnesium oxide is standard. Minimum insulation resistance to wire or wire to sheath is 1 GΩ at 500 Vdc in diameters above 1.5 mm (1/16").

**Calibration:** Iron-constantan (J), CHROME GA®-ALOMEGA® (K), copper-constantan (T), and CHROME GA®-constantan (E) are standard calibrations.

**Bending:** Easily bent and formed. Bend radius should be not less than twice the diameter of the sheath.

**Delivery:** Off-the-shelf. Other sheaths are available; call for price and delivery.

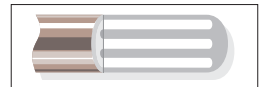
**Dual Elements:** Thermocouples with a sheath diameter of 1 mm (0.040") through 6 mm (1/4") are available in dual element.

**Accuracy:** The wires used in OMEGA® thermocouples are selected and matched to meet ANSI Limits of Error. Special limits of error thermocouples can be made from 0.25 mm (0.010") OD to 9.5 mm (0.375") OMEGA CLAD® thermocouple wire.

**ANSI Polarity\*:** In the thermocouple industry, standard practice is to color the negative lead red. Other standards that OMEGA® uses are: the negative lead of bare wire thermocouple is approximately 6 mm (1/4") shorter than the positive lead, and the large pin on a thermocouple connector is always the negative conductor. \*IEC polarity—standard practice is to color the negative lead white.

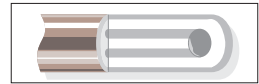
**Extension Wire:** Thermocouple alloy wire must always be used to connect a thermocouple sensor to the instrumentation to ensure accurate measurements.

Grounded Junction, OMEGA CLAD® Probes



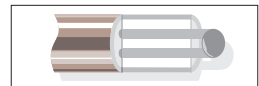
A **grounded junction** is recommended for the measurement of static or flowing corrosive gas and liquid temperatures and for high-pressure applications. The junction of a grounded thermocouple is welded to the protective sheath, giving faster response than the ungrounded junction type.

Ungrounded Junction, OMEGA CLAD® Probes



An **ungrounded junction** is recommended for measurements in corrosive environments it is desirable to have the thermocouple electrically isolated from and shielded by the sheath. The welded wire thermocouple is physically insulated from the thermocouple sheath by MgO powder (soft).

Exposed Junction, OMEGA CLAD® Probes



An **exposed junction** is recommended for the measurement of static or flowing non-corrosive gas temperatures where fast response time is required. The junction extends beyond the protective metallic sheath to give accurate, fast response. The sheath insulation is sealed where the junction extends to prevent penetration of moisture or gas, which could cause errors.



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