Introduction to Thermocouples and Thermocouple Assemblies

What is a thermocouple?
A thermocouple is a sensor for measuring temperature. It consists of two dissimilar metals, joined together at one end, which produce a small unique voltage at a given temperature. This voltage is measured and interpreted by a thermocouple thermometer.

What are the different thermocouple types?
Thermocouples are available in different combinations of metals or 'calibrations.' The four most common calibrations are J, K, T and E. There are high temperature calibrations R, S, C and GB. Each calibration has a different temperature range and environment, although the maximum temperature varies with the dia. of the wire used in the thermocouple.

How do I choose a thermocouple type?
Because thermocouples measure in wide temperature ranges and can be relatively rugged, they are very often used in industry. The following criteria are used in selecting a thermocouple:

- Temperature range
- Chemical resistance of the thermocouple or sheath material
- Abrasion and vibration resistance
- Installation requirements (may need to be compatible with existing equipment; existing holes may determine probe diameter).

How do I know which junction type to choose? (also see diagrams)
Sheathed thermocouple probes are available with one of three junction types: grounded, ungrounded or exposed. At the tip of a grounded junction probe, the thermocouple wires are physically attached to the inside of the probe wall. This results in good heat transfer from the outside, through the probe wall to the thermocouple junction. In an ungrounded probe, the thermocouple junction is detached from the probe wall. Response time is slower than the grounded style, but the ungrounded offers electrical isolation of 1 GΩ at 500 Vdc for diameters ≥ 0.15 mm and 500 MΩ at 50 Vdc for < 0.15 mm diameters. The thermocouple in the exposed junction style protrudes out of the tip of the sheath and is exposed to the surrounding environment. This type offers the best response time, but is limited in use to dry, noncorrosive and nonpressurized applications.

What is 'response time'?
A time constant has been defined as 'the time required by a sensor to reach 63.2% of a step change in temperature under a specified set of conditions. Five time constants are required for the sensor to approach 100% of the step change value.' Exposed junction thermocouples are the fastest responding. Also, the smaller the probe sheath diameter, the faster the response, but the maximum temperature may be lower. Be aware, however, that sometimes the probe sheath cannot withstand the full temperature range of the thermocouple type.

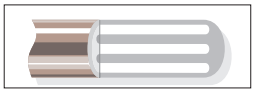
Operating Atmosphere – Typical Sheath Materials

Material	Maximum Temperature	Application Atmosphere			
		Oxidizing	Hydrogen	Vacuum	Inert
304, 310, 316, and 321SS	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 OMEGACLAD® 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.

OMEGACLAD® Specifications

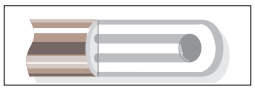
Diameters: Standard diameters: 0.25 mm (0.010"), 0.5 mm (0.020"), 0.75 mm (0.032"), 1 mm (0.040"), 1.5 mm (1/16"), 3 mm (1/8"), 4.5 mm (3/16"), and 6 mm (1/4") with two wires 8 mm (0.313") and 9.5 mm (0.375").
Length: Standard OMEGA® thermocouples have 300 mm (12 inch) immersion lengths. Other lengths available.
Sheaths: 304 stainless steel and Inconel are standard. Other sheath materials available; call for price and availability.
Insulation: High Purity Magnesium Oxide is standard. Minimum insulation resistance wire to wire or wire to sheath is 1 GΩ at 500 Vdc in diameters above 1.5 mm (1/16")
Calibration: Iron-Constantan (J), CHROMEGA®-ALOMEGA® (K), Copper-Constantan (T), and CHROMEGA®-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 available; call for price and delivery.
Dual Elements: Thermocouples with a sheath diameter of 1 mm (0.040") thru 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 (.010") O.D. to 9.5 mm (.375") OMEGACLAD®. 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.
Extension Wire: Thermocouple alloy wire must always be used to connect a thermocouple sensor to the instrumentation to assure accurate measurements.

Grounded Junction, OMEGACLAD® Probes



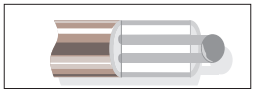
A **grounded junction** is recommended for the measurement of static or flowing corrosive gas and liquid temperatures and for high pressure applications. The junction of a grounded thermocouple is welded to the protective sheath, giving faster response than the ungrounded junction type.

Ungrounded Junction, OMEGACLAD® Probes



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

Exposed Junction, OMEGACLAD® 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.