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

<table>
<thead>
<tr>
<th>Material</th>
<th>Maximum Temperature</th>
<th>Application Atmosphere</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>Oxidizing</td>
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<tr>
<td>304, 310, 316, and 321SS</td>
<td>900°C (1650°F)</td>
<td>Very Good</td>
</tr>
<tr>
<td>Inconel 600</td>
<td>1150°C (2100°F)</td>
<td>Very Good</td>
</tr>
<tr>
<td>Super OMEGACLAD® XL</td>
<td>1335°C (2440°F)</td>
<td>Excellent</td>
</tr>
<tr>
<td>Platinum-Rhodium Alloy</td>
<td>1650°C (3000°F)</td>
<td>Very Good</td>
</tr>
<tr>
<td>Molybdenum</td>
<td>2200°C (4000°F)</td>
<td>Not Rec.</td>
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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 (¼”), 3 mm (½”), 4.5 mm (¾”), and 6 mm (⅝”) 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 (⅛”).

Calibration: Iron-Constantan (J), CHROMEGA®-ALOMEGA® (K), Copper-Constantan (T), and CHROMEGA®-Constantan (E) are standard calibrations.

Bending: Easily bent and formed.