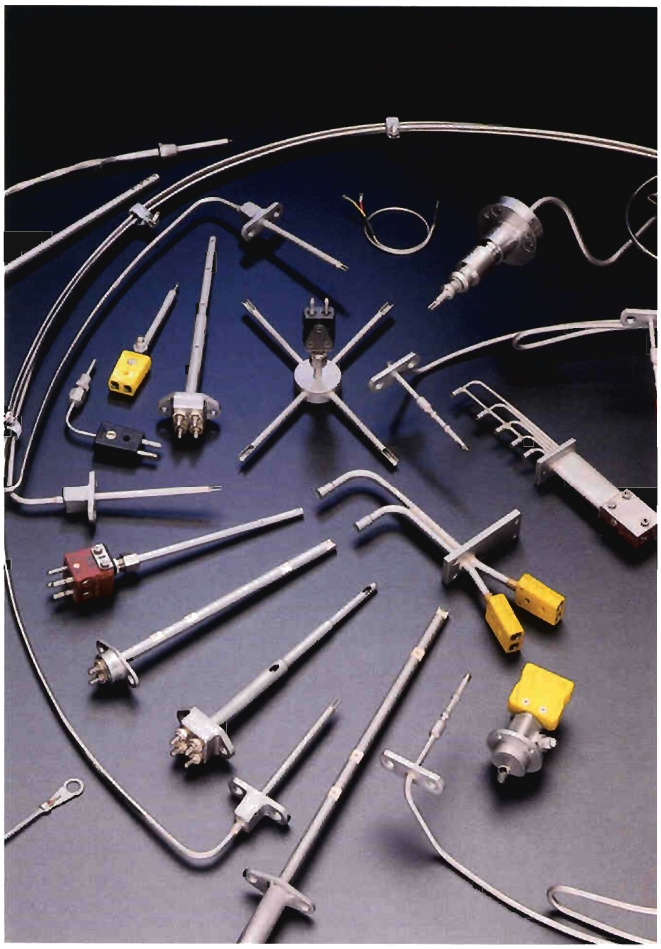
Fast Response Thermocouples

For Gas Turbines & Industrial Applications



WAHLCO, INC.

Miniaturization Specialist

High Compaction Insulation for Fastest Response Times

For ungrounded junctions, the high-density compaction of the thermocouple's insulating material is critical for the fast transfer of heat from the metal sheath to the wire junction. Compaction is also important for achieving maximum dielectric strength.

From years of manufacturing both thermocouples *and* premium tubular heater elements for critical industrial processes, Wahlco has perfected the technique of Swaged Compaction of Magnesium Oxide (MgO). Swaged compaction is especially important in reduced-tip designs. Magnesium Oxide is available in standard 96% purity or high 99.4% purity.

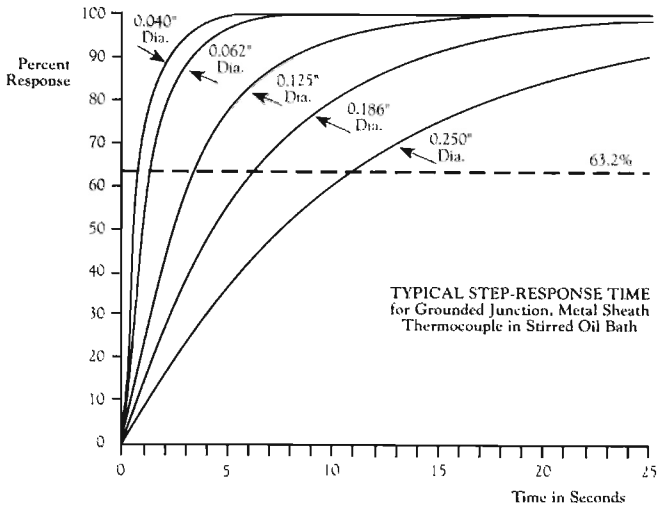
Insulated Wires

Thermocouple and thermocouple extension wire and cable are selected, matched, calibrated and made traceable to the National Institute for Science & Technology (NIST) for meeting ISA limits of error. All wires are color-coded for identification.

To assure accurate measurements, thermocouple extension wire and terminations must always be used to connect a thermocouple sensor to instrumentation.

Standard wire stocks include heavy-duty double fiberglass braid, laid over each single conductor, which are, in turn, laid parallel and braided together in a jacket of the same material. Other insulations such as polyvinyl and Teflon® are available. Special tolerance materials and stainless steel overbraids are also available.

Wire Diameter vs. Response Time For Mineral-Insulated Cable



Sheath Materials

Metal sheath diameters are available from .020" (.508mm) to .250" (6.35mm) and may be formed or shaped to virtually any contour with a radius greater than twice the sheath diameter.

Wahlco's standard sheath materials are stainless steel 304 and Inconel® 600. Also available as special orders are additional 300 Series stainless steels, Inconel® 601 and 625, Haynes® HR-160 and 214, and Hastelloy® X.

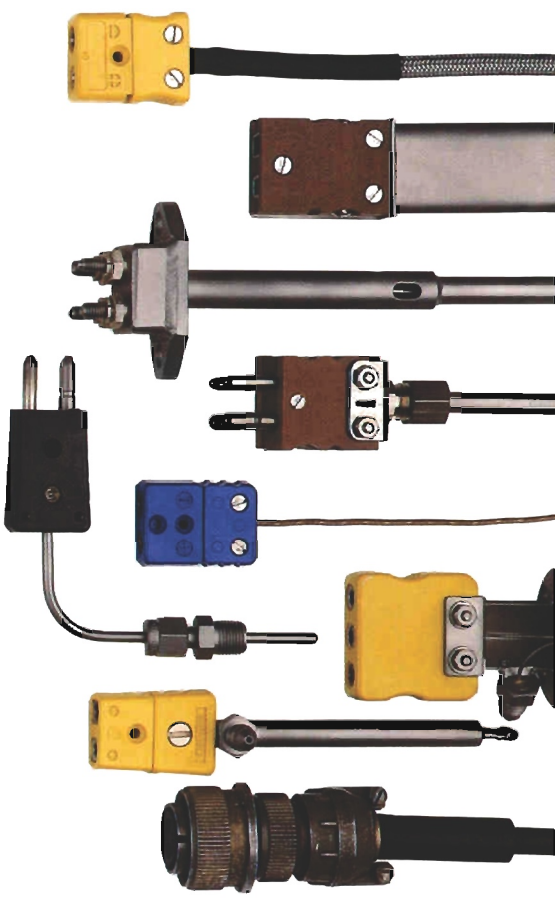
Mounting Fittings

Wahlco can provide virtually any type of thermocouple mounting fitting or flange needed, including brass and stainless steel NPT. Designs include fixed and adjustable length immersion fittings.

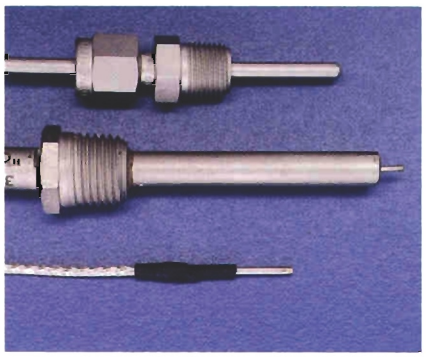
Connections

Wahlco thermocouples can have virtually any type of termination, including:

- Plugs & Jacks (standard, miniature, high-temperature or duplex)
- Screw Cover Head
- Potted Transitions (standard or high-temperature)
- Stripped Ends
- Spade Lugs
- Stud Terminals
- Cylindricals (commercial or mil-spec; moisture seal or strain relief).



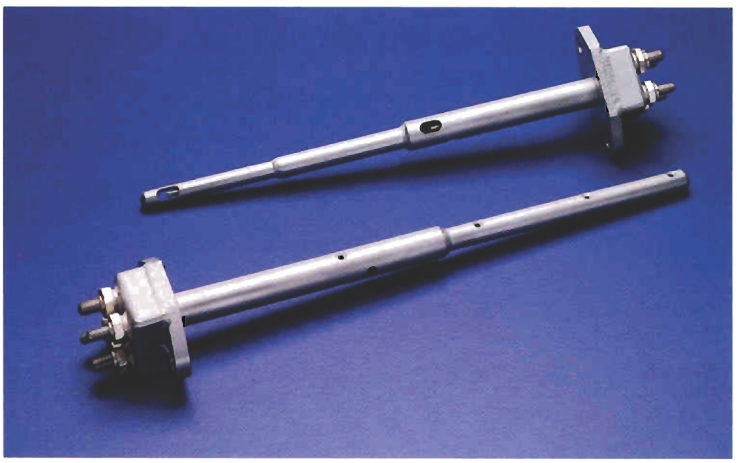
Thermocouple Configurations



Miniature Probes

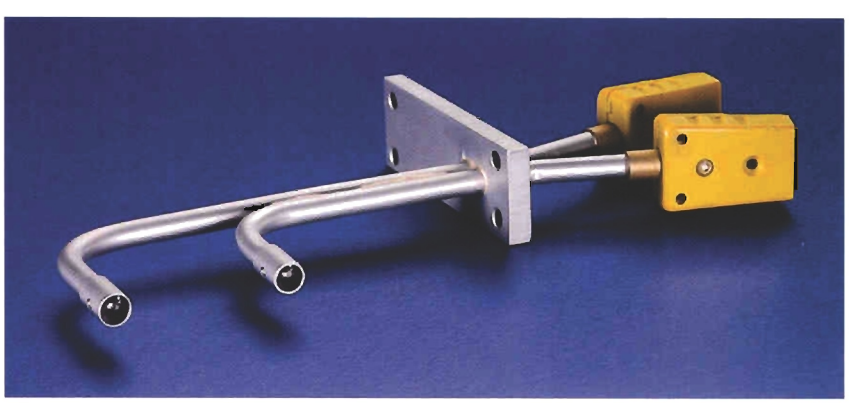
.063" diameter metal sheath thermocouples are ideal for fast response times in confined-space applications. Options include miniature NPT fittings, custom flanges, mini transition housings, mini potted transitions, and mini terminations.

Wahlco has over two decades of experience making high temperature miniature probes for such rugged applications as gas turbines. The small size of these probes makes them suitable for temperature sensing in bearing housings, electric machinery, and process and control instrumentation.



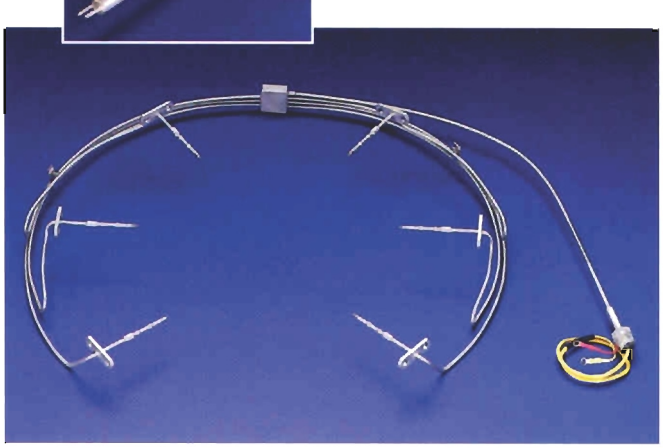
Stagnation Thermocouples

Stagnation thermocouples feature carefully-placed openings in the protective metal sheath that cause the rushing gas stream to "stagnate" as it passes by the sensing tip. This stagnation reduces the frictional heat created by the very high velocity gas streams and subsequently improves the accuracy of temperature sensing. Stagnation thermocouples can withstand high vibration and sudden temperature changes, and they are typically used in jet engines and gas turbines.



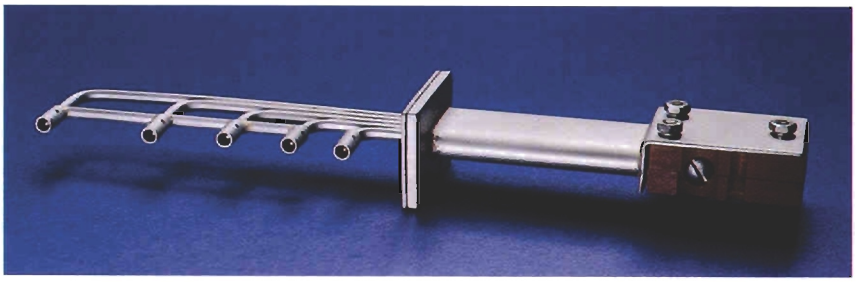
Probes

Wahlco thermocouple probes are offered with a wide range of mounting fittings and flanges, made from either brass or stainless steel. Fixed or adjustable-length immersion fittings are available.



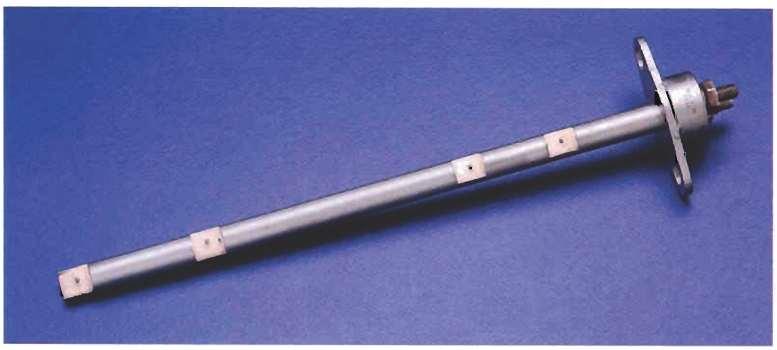
Harnesses

Wahlco has manufactured thousands of thermocouple harnesses for critical gas turbine applications. Conventional harnesses, as well as "modular legs" that allow the repair or replacement of a single leg of a multiple-leg harness, are available. Single or dual-tip probes with averaged or independent outputs can be specified. Also available are spherical "tube seals" fabricated along the metal sheath to provide gas-tight installation.



Averaging Rakes

Thermocouple rakes are used to measure temperatures at precise, pre-determined points in the gas stream. This particular thermocouple has .063 diameter sheaths with recessed, 28 gauge, exposed junctions that face the gas stream.

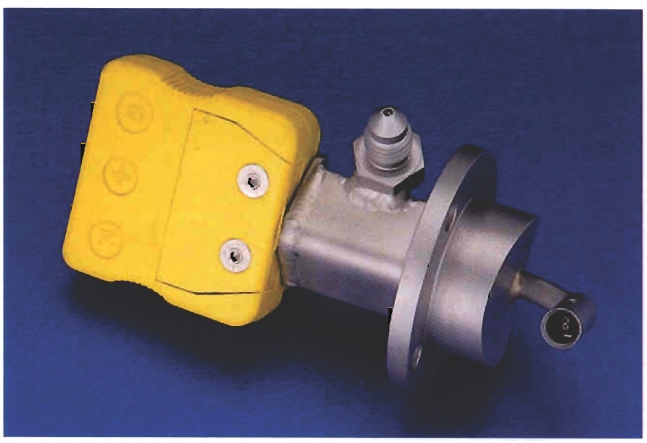


Multi-Point

Multi-point thermocouples feature exposed junctions that are designed to face high-velocity gas streams. High-temperature cement encapsulates and protects the thermocouple wires leading to the exposed junctions. Appropriate for averaging or independent temperature sensing.

Washer-Type

Washer thermocouples are frequently used to monitor local surface temperatures in engines and machinery. The measuring junction is virtually the entire gasket area. The sensor can be placed underneath existing bolts or screws.



Multi-Purpose (Pressure & Temperature)

An example of Wahlco's multi-purpose capacities, this design features a .020" sheath thermocouple and adjacent pressure probe recessed into an open-ended shield. Below the mounting flange is a pressure output fitting. The thermocouple is terminated with a grounded jack.

Custom Designs

Wahlco welcomes the opportunity to custom design and manufacture thermocouples for one-of-a-kind applications, in virtually any configuration. Applications that we have accommodated include very high pressures, extreme temperatures, special limit accuracies, and alloy sheath for very corrosive environments.

Quick Selector Guide To Thermocouple Materials

Specifiers need to consider the following criteria when selecting a thermocouple for an application:

- Temperature range
- Chemical resistance
- Abrasion & vibration resistance
- Installation requirements (hole size for probe, etc.)

Thermocouple Wire

Thermocouple Type & Applications	ANSI Type	Temperature Range °F	Limits of Error		Recommended Temperature Limits (Thermocouple in closed-end sheath)				
			Standard	Special	8 Gauge (0.128")	14 Gauge (0.064")	20 Gauge (0.032")	24 Gauge (0.020")	30 Gauge (0.010")
Copper vs. Constantan Suitable for subzero temperatures. Can be used in oxidizing, reducing, inert or vacuum atmospheres.	T	-300 to -75 -150 to -75 -75 to +200 +200 to +700	— ±2% ±1.5°F ±0.75%	±1% ±1% ±0.75°F ±0.375%	N/A	-300° to +700°F -185° to +370°C	-300° to +500°F -185° to +260°C	-300° to +400°F -185° to +205°C	-300° to +300°F -185° to +150°C
Chromel™ vs. Alumel™ Recommended for use in temperature ranges around 1000°F. Extended use above 1400°F reduces accuracy for temperatures below 900°F. Can only be used in vacuum for short time until calibration shifts.	K	0 to +530 +530 to +2300	±4°F ±0.75%	±2°F ±0.375%	0° to +2300°F -18° to +1260°C	0° to +2000°F -18° to +1093°C	0° to +1800°F -18° to +982°C	0° to +1600°F -18° to +871°C	0° to +1400°F -18° to +760°C
Iron vs. Constantan (Magnetic) Oxidation of iron wire accelerates above 1000°F, so heavier gauge wires should be used. Protect iron from ammonia, hydrogen and nitrogen. Can be used in oxidizing, reducing, inert or vacuum atmospheres.	J	0 to +530 +530 to +1400	±4°F ±0.75%	±2°F ±0.375%	0° to +1400°F -18° to +760°C	0° to +1100°F -18° to +593°C	0° to +900°F -18° to +482°C	0° to +700°F -18° to +371°C	0° to +600°F -18° to +316°C
Chromel™ vs. Constantan Good resistance to corrosion at low temperatures. Has highest EMF output of standard thermocouples. Can be used in oxidizing or inert atmospheres. Should not be used in reducing or vacuum atmospheres.	E	0 to +600 +600 to +1600	±3°F ±0.5%	— —	-300° to +1600°F -185° to +871°C	-300° to +1400°F -185° to +649°C	-300° to +1200°F -185° to +538°C	-300° to +800°F -185° to +427°C	-300° to +800°F -185° to +427°C
Nicrosil vs. Nisil	N	+32 to +545 +545 to +2300	±4°F ±0.75%	±2°F ±0.4%	+2300°F +1260°C	+2000°F +1100°C	+1800°F +1000°C	+1600°F +870°C	+1400°F +760°C
Platinum vs. 10% Rhodium	S	0 to +1000 +1000 to +2700	±5°F ±0.5%	±2.5°F ±0.25%	N/A	N/A	N/A	0° to +2700°F -18° to +1482°C	N/A
Platinum vs. 13% Rhodium	R	0 to +1000 +1000 to +2700	±5°F ±0.5%	±2.5°F ±0.25%	N/A	N/A	N/A	0° to +2700°F -18° to +1482°C	N/A
Platinum 30% vs. 6% Rhodium	B	+1600 to +3100	±0.5%	±0.25%	N/A	N/A	N/A	+1600° to +3100°F +871° to +1705°C	N/A

Note: Temperature limits are for continuous temperature sensing by standard thermocouples with closed-end protective metal sheaths. Exposed tip thermocouples require that these limits be reduced for equivalent service life.

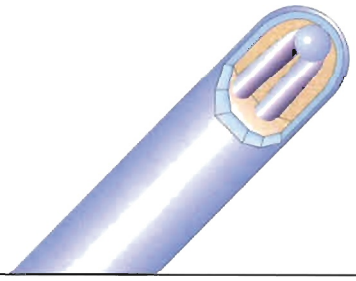
Standard Sheath Materials for Mineral-Insulated Cable

Material	Maximum Temperature	Application Atmosphere				Typical Applications
		Oxidizing	Hydrogen	Vacuum	Inert	
304 Stainless Steel Magnesium Oxide Insulated	1700°F (927°C)	Very Good	Good	Very Good	Very Good	Recommended for general applications, including food, chemical, petroleum refining, plastics, and steam lines. Not affected by foodstuffs, most dyestuffs, sterilizing solutions, organic chemicals and many inorganic chemicals. Subject to carbide precipitation in 800° to 1000°F (430° to 540°C) range.
Inconel™ 600 Magnesium Oxide Insulated	2100°F (1149°C)	Very Good	Good	Very Good	Very Good	Appropriate for severely corrosive environments at elevated temperatures. Resistant to progressive oxidation and fatigue. High "hot strength." Non-magnetic. Recommended for gas furnaces, lead baths, open hearth fluestacks, waste heat boilers, incinerators, ore roasters, cement exit flues, and bath mixtures containing cyanide. Environment must be sulphur-free above 1000°F (540°C).

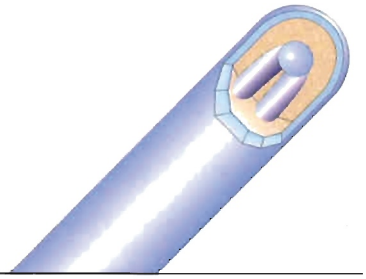
Application Guide

Junction Styles

Exposed Junction—*For the fastest response times. Appropriate for measuring static or flowing gas temperatures in non-corrosive, non-contaminating environments.*



Grounded Junction—*For corrosive environments and high-pressure applications. The junction is welded to the protective metal sheath, providing faster response times than ungrounded designs.*



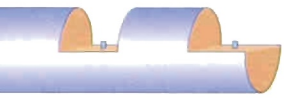
Ungrounded Junction—*For measuring temperatures of corrosive gases or liquids. Ungrounded junctions are recommended when nearby electrical apparatus or conductive media would create stray EMFs that would affect the thermocouple's performance. The ungrounded junction is also mechanically isolated from the protective metal sheath, offering maximum protection from thermal shock and vibration.*

Tip Designs

Round Tip—Appropriate for high velocity air/gas streams to avoid erosion-causing "eddies." Available with ungrounded or grounded junctions.

Flat Tip—For maximum surface-to-surface contact when mounting a thermocouple perpendicular to an object. Available with ungrounded or grounded junctions.

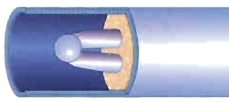
Tapered Tips—For applications requiring the mechanical strength of a larger diameter metal sheath, but with the fast response time of smaller diameter tips. Wahlco's swaging of the metal sheath allows for a reduction of up to 50% of the starting sheath diameter. Available with ungrounded or grounded junctions.



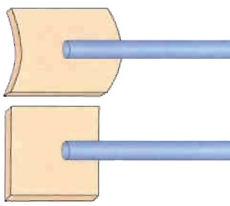
Partially Exposed—The fast response of an exposed junction, but with high-temperature cement protecting the thermocouple wires from erosion and contamination. Designed so the junction(s) faces the on-coming air/gas stream. Frequently used in multi-point assemblies.

Recessed within Perforated Shield—Protects the thermocouple tip in very high velocity air/gas streams. The perforated shield also regulates the velocity of the air/gas stream that the tip sees, permitting "stagnation" temperature measurements. Perforated design can also be used to shield the tip from undesirable radiant energy heat. Typically used with "exposed" junctions recessed into the perforated sheath.

Recessed within Solid Shield—Features an "exposed" junction recessed into a protective, open-ended sheath. If pointed upstream, the open-end design can stagnate the velocity of the air/gas stream, with one or more bleed holes allowing the air to escape.

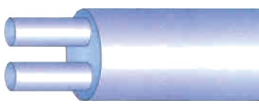


Semi-Shield—The half sheath protects exposed tip from a hostile gas stream. Used to extend the life of the exposed tip, as well as the MgO insulation.



Weld Pads—For surface temperature measurement of boiler tubes, tanks and pipes. The weld pad can be flat or contoured to match the surface geometry. Pad size and alloy pad material are selected to be compatible with the host surface. Attachment of the thermocouple to the pad can be done in any orientation.

Dual Element—Capable of taking two independent temperature measurements at one point (for example, for monitoring and control functions). Can also be used for averaging measurements. Dual elements are sometimes specified for redundant (spare) capacity in very critical applications.



Dual Coaxial—For applications needing the fast response time of an exposed tip, but also requiring the strength and rigidity of the heavier coaxial tip construction. Dual tips can be used for independent readings, averaging, or redundancy.

Sheath outer diameter limitations apply depending upon junction style and tip design. All designs shown above are for mineral-insulated cable.

Quality Assurance

In addition to our standard Quality Assurance Program, Wahlco works closely with customers to develop comprehensive inspection and testing programs tailored to meet their specific applications.

Wahlco's quality assurance programs have met the rigorous requirements and specifications of major gas turbine and industrial equipment manufacturers. Typically our customers' guidelines include current industrial and/or military specifications and standards. Approved, controlled-process manufacturing methods are used for all:

- Brazing
- Fusion Arc Welding
- Soldering
- Spot Welding

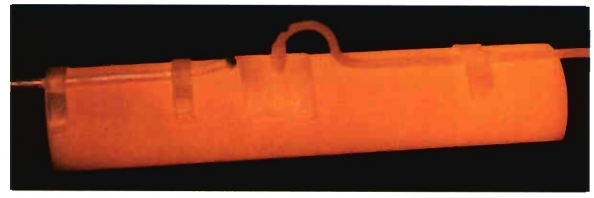
Testing and calibration being done at our Santa Ana facility.

Wahlco quality assurance procedures include:

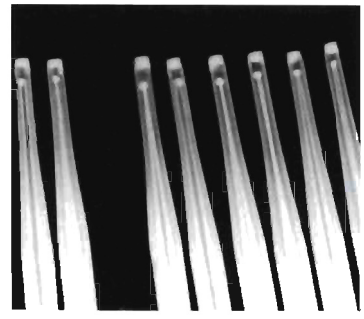
- High temperature baking to ensure high insulation resistance properties between the thermal conductors and sheath.
- Circuit loop resistance test.
- 100% radiograph inspection of junctions and tips on small diameter sensors to detect voids and cracks, as well as to verify dimensions.
- All instrumentation is regularly calibrated to NIST standards.
- Material traceability of original source maintained for at least three years.

In addition to the standard procedures listed above, Wahlco can perform numerous special quality assurance tests, including:

- Thermal response time of sensor tip and junction.
- Immersion thermal shock for weld and braze integrity.
- Dye penetrant testing for detection of small surface defects.
- Hydrostatic pressure testing to 1000 psi.
- Dielectric strength (hypot) testing for performance of conductor insulations.
- Hot and cold testing for spurious junctions in the sensor circuit.
- Calibration and matching of harnesses, rakes, and multi-point outputs.
- Helium leak or ultrasonic testing of welded connections.
- Independent metallurgical laboratory verification of materials.



Thermocouple testing at 2100°F. The thermocouples are mounted on a boiler tube shield; the thermocouple on the left is measuring temperature near the tube shield; the (tubeskin) thermocouple on the right is directly measuring tube shield temperature.



Radiograph inspection of ungrounded tapered thermocouples. Diameters are 0.125," swaged to 0.063," with Inconel® 600 sheaths for gas turbine exhaust duct measurement.

Fast Delivery

A customer called on Wednesday, needing this bearing thermocouple for a Friday shipping of an auxiliary power unit. Wahlco was able to make the deadline. Although this is an extreme example, Wahlco's customers are continually impressed with how fast we can design and manufacture custom thermocouples.

WAHLCO, INC.

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