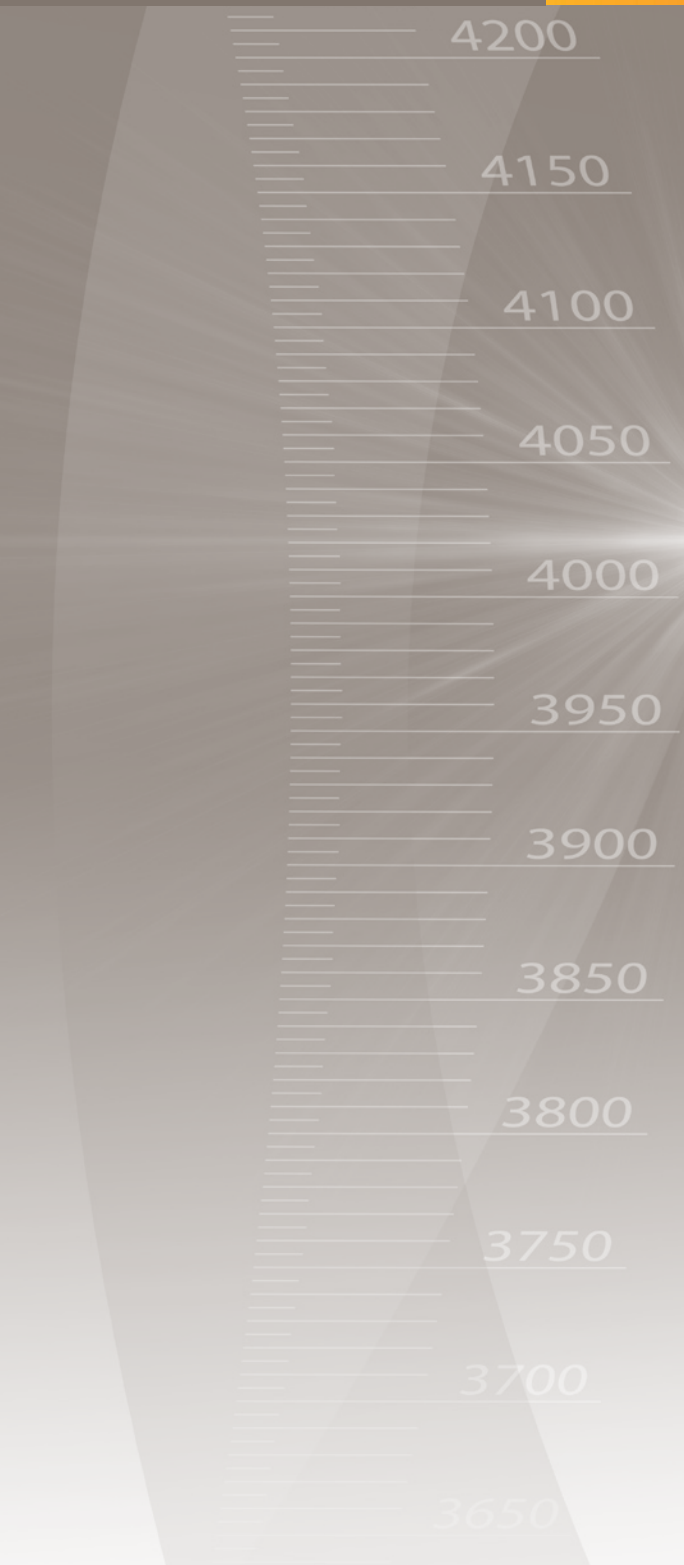
Thermocouples for Ultra High Temperature Technologies



Vulcan

Tungsten Coated Probes

Operating Temperatures up to 4200F (2315C)

- Molybdenum and tantalum tungsten coated sheaths
- Refractory Metal, Inconel, or Stainless Steel support tube protects refractory sheath
- Extra heavy coated layers available
- Single, Dual, and Multipoint elements (0.010"- 30 ga (0.254 mm), .020"- 24 ga (0.508 mm)
- Probe Dia. 0.125" thru 0.285" (Metric available)
- Hafnia oxide insulation
- Coating reduces the carburization action, provides increased abrasion resistance and extends probe life

Control, multipoint and over temperature

Calibrations- C (W5), D, G, R, S ,B

Typical Applications: Graphite furnaces, Hot Isostatic Presses, Crystal Growth, Sapphire

Molybdenum & Tantalum Probes

Operating Temperatures up to 4200F (2315C)

- Designed for extreme conditions of temperature, time and cycling
- Additional Refractory materials: Pure Tungsten, Moly-Rhenium
- Probe Dia. 0.125" thru 0.285" (Metric available)
- Hafnia oxide insulation
- Single, Dual, and Multipoint elements (0.010"- 30 ga (0.254 mm), .020"- 24 ga (0.508 mm)
- High Integrity seal for vacuum tight applications.

Control, multipoint and over temperature

Calibrations-C (W5), D, G, R, S, B

Typical Applications: Vacuum Furnaces and related process industries, including Crystal growing, Chemical Vapor Deposition, For the Industrial, Solar, Semiconductor, Opto-electronic, MEMS and Nanotechnology market.

Ceramic Thermocouple Assemblies

Operating Temperatures up to 3400F (1871C)

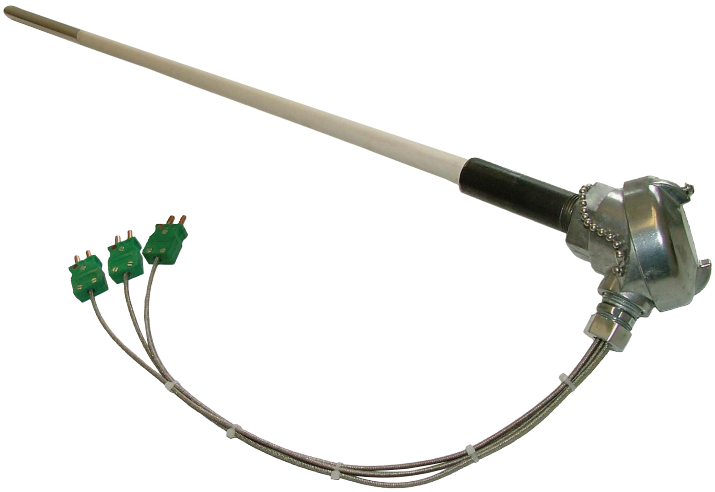
- Innovative double seal on cold end for optimum process integrity in vacuum or gas environments
- Offered in a variety of standard and metric sizes
- Available in several process installation configurations.
- Single, dual and multi junctions
- Aluminum, Cast Iron and Explosion Proof Enclosures.

Control, multipoint and over temperature

Calibrations-C (W5), D, G, R, S, B, K, N, PII

Typical Applications: Metal treatment, Brick & ceramic Kilns, Glass and Quartz Industries.

Platinum Coated Alumina Thermocouples



Operating Temperatures up to 2800F (1537C)

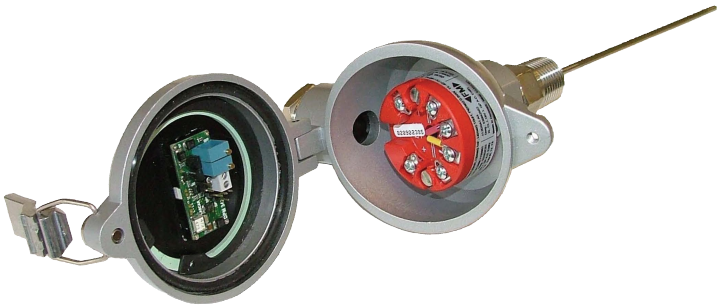
- Designed for uniform and accurate temperature measurement of molten glass tanks
- Excellent long life in oxidizing atmospheres
- A small section is coated with a thin layer of platinum at the closed end of the ceramic protection tube to facilitate temperature measurements of the molten glass contained in the tank
- Replaces the high cost of the full platinum thimble construction
- Single, Dual, and Multipoint elements
- Variety of cold end terminations

Control, over temperature, and profile

Calibrations- R, S, B

Typical Applications: Glass Crown and Bottom Melt Furnaces

Transmitter/Converter Designs



Applications where either distance or Electrical interference is a problem

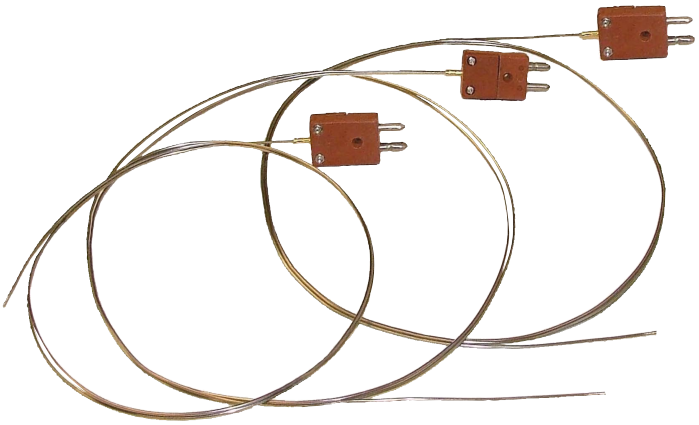
- Conversion to 4 to 20 ma signal for communication to control devices
- Variety of enclosure options available
- Suitable for all high temperature thermocouple calibrations as well as lower ones
- Head and DIN Rail Mounting options
- Explosion proof with certification

Control and over temperature

Calibrations- All

Typical Applications: All industries

Bendable Sheath Thermocouples



Operating Temperatures up to 4200F (2315C)

- Engineered as an economical solution to out perform ceramic fiber wire insulated thermocouples
- Bendable construction for simplified installation and connections to jack panels
- Probe Dia. 0.125" thru 0.240" (Metric available)
- Sheath materials: Inconel, Pyrosil, Hastelloy, Stainless, Tantalum
- Single or dual junctions
- High purity Magnesium, Alumina, Hafnia Oxide insulation

Work Load and survey thermocouples

Calibrations- C (W5), D, G, R, S, B, K, N, PII

Typical Applications: Furnace Surveys for all vacuum, inert gas, and atmosphere furnaces.

Replacement Thermocouple Elements

Individual platinum elements as well as Components to fit all OEM Furnaces for Solar Manufacturers & Crystal Growth

- Manufactured to original specification
- High purity Alumina Oxide insulators
- Probe Dia. 0.062" thru 0.250" (Metric available)
- Recessed style ceramic tip providing protection for the platinum hot junction
- Exchange program, save old thermocouple for credit towards new thermocouple.
- Wire sizes: 0.010" - 30ga (0.254mm), .020" - 24ga (0.508mm)
- Reference or Standard Grade wire

Control, over temperature and profile

Calibrations- R, S, B, PII, C, D, G, K, N

Typical Applications: All Solar Industries, PV, multi-crystalline silicon ingots, thin film, Semiconductor, Optoelectronics, LED., Crystal growing methods, HEM, EFG & Top Seeded Solution Growth.

Tungsten Coated Custom

Operating Temperatures up to 4200F (2315C)

- Diameters precision ground to exacting specifications, allowing use of 1/8" o.d. feedthroughs
- Sensitive to oxidation above 392 F (200C)
- Single, dual and multi junctions
- High integrity seal for vacuum tight applications

Control, multipoint and over temperature

Calibrations: C(W5), R, S, B

Typical Applications: Vacuum Furnaces and Related process industries, including Crystal Growth and CVD for the following industries: Solar, Semiconductor compounds, Opto-Electronic, MEMS, and Nano Technologies. SiC and Graphite Hot Presses

Re-crystalized Silicon Carbide Thermocouples

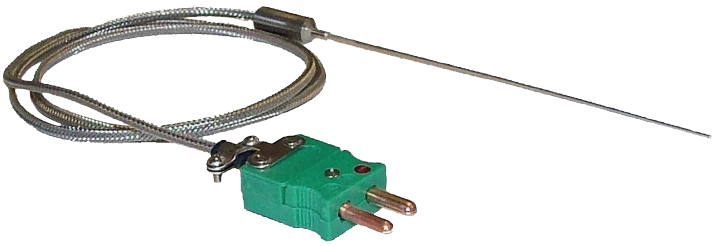
- Developed for corrosion resistance environments with extreme acid and alkali levels
- Configured for installation within flues
- Standard or custom fittings and termination heads
- Single and Dual elements

Control and over temperature

Calibrations: R, S, B, K, N

Typical Applications: Chemical incineration, Bio-waste Treatment Facilities, Co-generations plants

Composite Sheathed Thermocouples

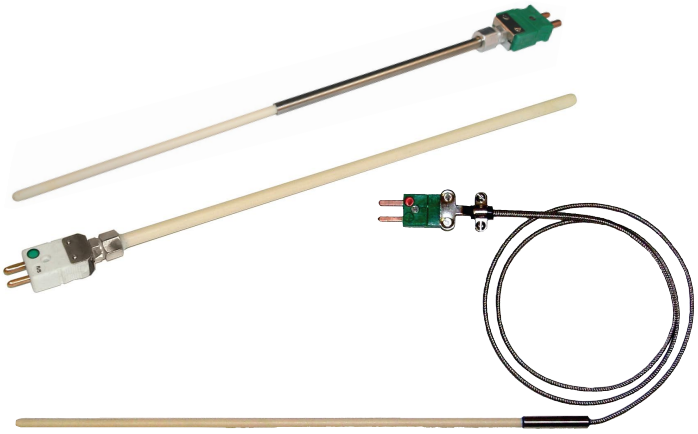


- Engineered to reduce the cost of all platinum sheath cable
- Only a small portion of the thermocouple cable subjected to high temperature utilizes the platinum sheath welded to the inconel sheath
- Probe Dia. 0.125" thru 0.250" (Metric available)
- Precious metal and base metal sheath combinations
- Single or multiple junctions as shown

Calibrations: R, S, & B

Typical Applications: Gas turbine combustor discharge, Glass melting and working, Ceramic sintering, Refractory erosion monitoring

Alumina Oxide Sheathed Thermocouples



- Innovative double seal on cold end for optimum process integrity in vacuum or gas environment
- Substitution for high cost refractory offered in a variety of standard and metric sizes
- Available in several process installation configurations, with or without support tube
- Single, dual and multi junctions
- Aluminum, Cast Iron and Explosion Proof Enclosures.

Calibrations: R, S, B, & C (W5)

Typical Applications: Solar processes, Metal treatment, Brick & ceramic Kilns, Glass and Quartz Industries.

Hexoloy™ Thermocouple Designs

- Well-matched thermocouple assemblies for production of synthesis gas or syngas used to power turbines for the Co-energy technologies
- Non-wetting for most non-ferrous metals, Aluminum, Cu, Zn, Brass, etc. making it very resistant to build up of dross and therefore very low maintenance.
- Exceptional wear resistance – 50% harder than tungsten carbide
- Excellent Thermal Shock resistance and high temperature strength –won't slump at 3000F (1649C) even under load
- Thermal expansion match to silicon, high elastic modulus, chemical inertness

Calibrations: R, S, B, & C (W5)

Typical Applications: Gasification technologies, Semiconductor technologies, Molten non-ferrous metals technologies

(Hexoloy is a registered trademark of Saint-Gobain Ceramics)

Pure Tungsten Sheath Thermocouples

Tungsten, 6165F (3407C)
Not embrittled by hydrogen

- Operating Temperatures up to 4200F (2315C) note: Tungsten sheath 6165F (3407C).
- Probe Dia. 0.125" thru 0.250"
- Hafnia Oxide insulation
- Single, dual and multi junctions
- High Integrity seal for vacuum tight applications.

Calibration: Type C (W5)

Typical Application: High temperature crystal-growth environments

International Thermocouple Color Codes
Thermocouple and Extension Grade Wires

Alloy Combination	U.S. & Canadian ANSI MC 96.1 - ASTM E320 Thermocouple Grade	U.S. & Canadian ANSI MC 96.1 - ASTM E320 Extension Grade	International IEC 584-3	Czech British BS-1843	Netherlands German DIN 43710	Japanese JIS C 1610	French NFC 42-324
J Constantan (-) Iron (+)	**Brown** Red (-) White (+)	**Black** Red (-) White (+)	**Black** White (-) Black (+)	**Black** Blue (-) Yellow (+)	**Blue** Blue (-) Red (+)	**Yellow** White (-) Red (+)	**Black** Black (-) Yellow(+)
K Alumel (-) Chromel (+)	**Brown** Red (-) Yellow (+)	**Yellow** Red (-) Yellow (+)	**Green** White (-) Green (+)	**Red** Blue (-) Brown (+)	**Green** Green (-) Red (+)	**Blue** White (-) Red (+)	**Yellow** Purple (-) Yellow (+)
T Constantan (-) Copper (+)	**Brown** Red (-) Blue (+)	**Blue** Red (-) Blue (+)	**Brown** White (-) Brown (+)	**Blue** Blue (-) White (+)	**Brown** Brown (-) Red (+)	**Brown** White (-) Red (+)	**Blue** Blue (-) Yellow (+)
N Nisil (-) Nicrosil (+)	**Brown** Red (-) Orange (+)	**Purple** Red (-) Orange (+)	**Pink** White (-) Pink (+)	**Orange** Blue (-) Orange (+)	No Standard (Use American Color Codes)	No Standard (Use American Color Codes)	No Standard (Use American Color Codes)
E Constantan (-) Chromel (+)	**Brown** Red (-) Purple (+)	**Orange** Red (-) Purple (+)	**Purple** White (-) Purple (+)	**Brown** Blue (-) Brown (+)	**Black** Black (-) Red (+)	**Purple** White (-) Red (+)	**Purple** Purple (-) Yellow (+)
R Platinum (-) Platinum-Rhodium 13% (+)	None Established	**Green** Red (-) Black (+)	**Orange** White (-) Orange (+)	**Green** Blue (-) White (+)	**White** White (-) Red (+)	**Black** White (-) Red (+)	**Green** Green (-) Yellow (+)
S Platinum (-) Platinum-Rhodium 10% (+)	None Established	**Green** Red (-) Black (+)	**Orange** White (-) Orange (+)	**Green** Blue (-) White (+)	**White** White (-) Red (+)	**Black** White (-) Red (+)	**Green** Green (-) Yellow (+)
B Platinum-Rhodium 6% (-) Platinum-Rhodium 30% (+)	None Established	**Gray** Red (-) Gray (+)	**Gray** White (-) Gray (+)	No Standard (Use Copper Wire)	**Gray** Gray (-) Red (+)	**Gray** Gray (-) Red (+)	No Standard (Use Copper Wire)
C Tungsten-Rhenium 26% (-) Tungsten-Rhenium 5% (+)	None Established	**Red** Red (-) Red (+)			No Standard (Use American Color Codes)	No Standard (Use American Color Codes)	No Standard (Use American Color Codes)

Technically advanced products... State of the art production and test capabilities...

Vulcan Electric Company -Thermal Division presents its most advanced line of temperature sensors for extreme process applications. These thermocouples have been developed from decades of experience at solving thermal application problems for the world's leading industrial producers and research facilities. Our sensors incorporate premium construction materials, advanced manufacturing techniques and the most precise test methods.

Vulcan employs state of the art equipment such as an Alcatel ASM142 Helium Leak Detector. This fully automatic equipment provides advanced leak detection capabilities for our ultra-high temperature thermocouples that are back-filled with inert gas and sealed. Thermocouples of this construction type often include vacuum feedthroughs and flanges for application into vacuum or atmospheric furnaces that are used in critical process applications such as crystal growth and advanced ceramics. With the capability of detecting minimum helium leaks of 1.10-11 atm. cc/s, Vulcan can ensure superior end seal integrity and the detection of micro-cracks in thermocouple materials such as the sheath. The enhanced leak testing process eliminates premature thermocouple failure attributed to undetected leaks using other test methods that are often employed in the thermocouple industry. This new technology is an important component to Vulcan's temperature sensor capabilities and compliments an already extensive array of production, in-house test, and calibration equipment that is vital to our commitment to services and quality.

Vulcan

Headquartered in Porter, Maine USA, we take pride in our traditional values and the importance of providing our customers with quality engineered products and exceptional service. We realize that in today's competitive global environment we must continually strive for superior product performance, excellence in our manufacturing operations, and deliver outstanding value to our customers. Our success depends on your success with every Vulcan product purchased.

In addition to the Thermocouples for Ultra High Temperature Technologies, we design and manufacture the following product lines:

Precision Thermocouples for Silicon Process Technologies

Thermocouple Calibration and Repair Services including our Flexible Thermocouple Management Programs

A complete range of Temperature Sensor Assemblies including General Industrial Thermocouples, RTDs, and Thermistors

Temperature switches including the versatile Cal-stat Cartridge Thermostats in 1/4", 1/2" and 5/8" diameters with several mounting constructions

Metal sheathed Heating Elements including Tubulars, Finned Tubulars, Cartridge, Strips, and Finned Strips in standards and custom configurations.

Heater Assemblies including Bushing Immersions, Flanged Immersions, Duct, Over-the-Side, Process Air, Preweld, and custom designs

Flexible and Rigid-Flex Circuits including our diverse manufacturing process capabilities for multiple layer circuitry in combination with many specialized features

TRC

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Product Configurator

UHT - 1 - 2 - 3 - 4 - 5 - 6 - 7 - 8 - 9 - 10

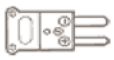
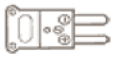
1 Probe Angle

A = Straight

B = 45 deg (specify location)

C = 90 deg

2 Cold End Termination

M = Standard size plug	
M800 = Standard size 800 F (417 C) thermoplastic Plug	
MCX = Standard size unglazed ceramic plug	
MM = Miniature size plug	
MMCX = Miniature size unglazed ceramic plug	
N = Standard size Jack	
N800 = Standard size 800 F (417 C) thermoplastic Jack	
NCX = Standard size unglazed ceramic jack	
NM = Miniature size Jack	
NMCX = Miniature size unglazed ceramic jack	
MN = Standard size plug and jack	
MNCX = Standard size unglazed ceramic plug and jack	
MNM = Miniature size plug and jack	
NMCX = Miniature size unglazed ceramic plug and jack	
L = 4″ split leads with lugs	
Q = 4″ split leads without lugs	

3 Probe Diameter

1/8"

5/32″

3/16″

1/4″

5/16″

3/8″

7/16″

1/2″

11/16″

3/4″

4 Probe Material

IN = Inconel

SS = Stainless Steel

MO = Molybdenum

TCM = Tungsten Coated Molybdenum

TA = Tantalum

PL = Platinum

TU = Tungsten

G = Graphite

PD = Pyrosil

AL = Alumina

HC = Hastelloy “C”

HY = Hastelloy “Y”

HX = Hexoloy

MT = Mullite

QZ = Quartz

5 Lead Length (in inches)

6 Lead Style

X = Flexible Stainless Steel armor protecting fiberglass insulated thermocouple wire

XBR = Stainless steel braid over fiberglass insulated thermocouple wire

XO = Fiberglass insulated thermocouple wire

GG = Fiberglass over fiberglass thermocouple wire

TT = Teflon insulated thermocouple wire

7 Probe Length (in inches)

8 Thermocouple Type

R = Platinum 13% Rhodium vs. Platinum

S = Platinum 10% Rhodium vs. Platinum

B = Platinum 30% Rhodium vs. Platinum 6% Rhodium

C = Tungsten 5% Rhenium vs. Tungsten 26% Rhenium

D = Tungsten 3% Rhenium vs. Tungsten 25% Rhenium

G = Tungsten vs. Tungsten 26% Rhenium

K = Chromel vs. Alumel

N = Nicrosil vs. Nisil

PII = Platinel II

9 Junction Construction

G = Grounded

U = Ungrounded

E = Exposed

10 Insulation Material

ALO = Alumina Oxide (Max. Temp. 3500 F / 1950 C)

HF = Hafnia Oxide (Max. Temp. 4200 F / 2315 C)

MT = Mullite (Max. Temp. 3000 F / 1650 C)

EXAMPLE: UHT-A-M-1/8-MO-6"-TT-6"-R-U-ALO

UHT	Ultra High Temperature (Product Code Prefix)
A	Probe Angle: Straight
M	Cold End Termination: Standard size plug
1/8″	Probe Diameter: 1/8″
MO	Probe Material: Molybdenum
6″	Lead Length: 6″
TT	Lead Style: Teflon insulated thermocouple wire
6″	Probe Length: 6″
R	Thermocouple Type: R
U	Junction Construction: Ungrounded
ALO	Insulation Material: Alumina Oxide

Expert engineered product experience for the following industries:

- Solar Cell Manufacturing
- Alternative Energy Research & Development
- Crystal Growth, SIC, Sapphire
- Syngas Renewable Energy
- Graphite Processes
- Exotic Refractory Metals Production
- Advanced Ceramics
- Composite Materials
- Semiconductor Compounds
- Vacuum Furnaces
- Quartz & Glass Products
- Biohazard Incineration
- Metallurgical Heat Treatment Processes
- Jet Engine Investment Castings

High Temperature Sheath Materials

Sheath Type	Vulcan Symbol	Recommended Temperature	Melting temp.	Allowable Environment	Minimum Bend Radius
Inconel 600	IN	1175C / 2147F	1345C / 2453F	Inert, Oxidizing, Vacuum	5 X Sheath Diameter
Platinum 10% Rhodium	PL	1550C / 2822F	1850C / 3362F	Inert, Oxidizing	5 X Sheath Diameter
Tantalum	TA	2200C / 3992F	2885C / 5423F	Inert, Vacuum	10 X Sheath Diameter
Molybdenum	MO	2000C / 3632F	2620C / 4748F	Inert, Vacuum, Reducing	Do Not Bend
Tungsten Coated Molybdenum	MOT	1600C / 2912F	2000C / 3632F	Inert, Oxidizing, Graphite	Do Not Bend
Tungsten	TU	2200C / 3992F	3407C / 6165F	Inert, Oxidizing, Hydrogen	Do Not Bend
Hexoloy	HX	2300C / 4172F	2300C / 4172F	Universal corrosion resistance	Do Not Bend
Pyrosil D	PD	1250C / 2280F	1380C / 2510F	Oxidation & Corrosion Resistance	5 X Sheath Diameter

High Temperature Insulation

Insulation Type	Vulcan Symbol	Recommended Temp.	Melting temp.	Comments
Magnesium Oxide (99.4%)	MgO	1700C / 3092F	2800C / 5072F	Used in bendable sheaths
Alumina Oxide (99.7%)	AL	1550C / 2822F	2050C / 3704F	Excellent with Platinum alloys
Hafnia Oxide	HF	2200C / 3992F	2650C / 4802F	Comparable to Beryllia Oxide and safe to handle

High Temperature Wire Types

Thermocouple Combinations	Calibration Symbol	Recommended Temperature	Std. Limits of Error	Special Limits of Error
Platinum 13% Rhodium VS. Platinum	R	0 -1450C / 32- 2640F	+/-1.5C or +/-0.25%	+/-.6C or +/-0.1%
Platinum 10% Rhodium VS. Platinum	S	0-1450C / 32-2640F	+/-1.5C or +/-0.25%	+/-.6 C or +/-0.1%
Platinum 30% Rh VS. Platinum 6% Rh	B	870-1700C / 1598-3092F	+/-0.5%	+/-0.25%
Tungsten 5% Re VS. Tungsten 26% Re	C (W5)	400-2300C / 752-4172F	+/1%	+/-0.5%
Chromel VS. Alumel	K	0-1250C / 32-2282F	+/-2.2C or +/-0.75%	+/-1.1C or +/-0.4%
Nicrosil VS. Nisil	N	0-1300C / 32-2372F	+/-2.2C or +/-0.75%	+/-1.1C or +/-0.4%
Platinel II	PII	200-1200C / 392-2192F	consult factory	consult factory