Thermocouples

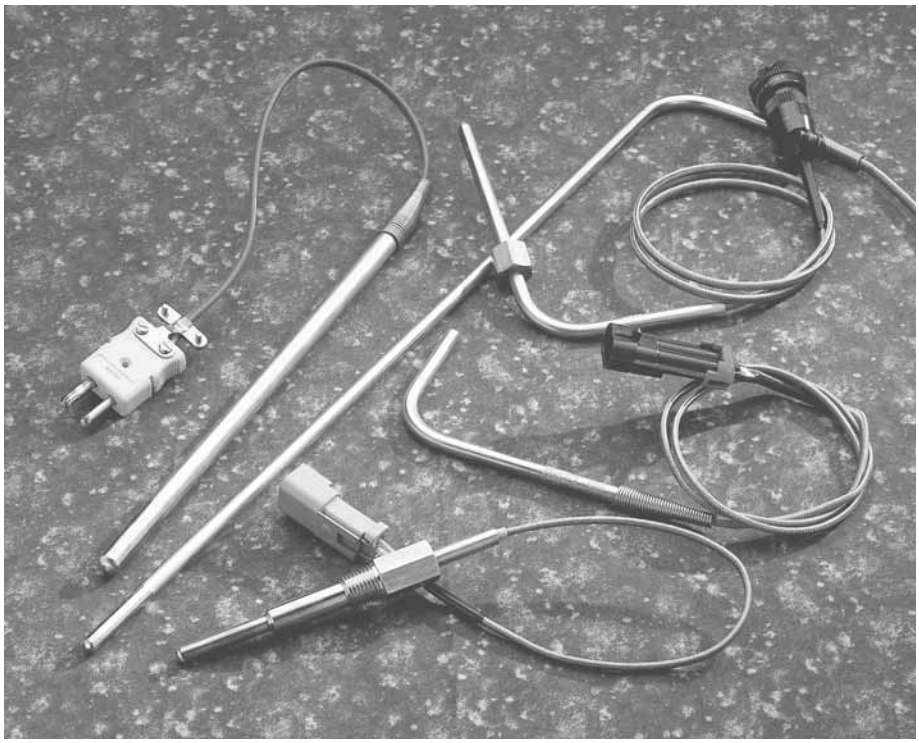
High Temperature

For Demanding Applications

Technological advances have created a demand for thermocouple materials with unusually high performance characteristics and superior quality. Watlow has kept pace with these demands. A long time leader in the field of temperature measurement, we have the modern facilities necessary to comply with today's complex specifications, standards and industrial or governmental regulatory requirements. We also provide testing and certification services to document compliance with agency standards. Our products are proof that we meet the challenge of reliability and high performance.

Performance Capabilities

- Compliance with recognized agency tolerances and specifications
- Temperature ranges up to 2315°C (4200°F)
- NIST traceable calibration certificates
- Thermocouple limits set to ITS-90 reference standards



Features and Benefits

Thermocouple conductors
- Ideal for all temperature applications

Wide selection of sheath materials
- Meet specific application requirements

Insulation materials
- Meet demanding application temperatures

Grounded and ungrounded junctions
- Meet electrical configurations

Testing and certification services
- Ideal for demanding applications

Applications

- Semiconductor manufacturing
- Diesel engines
- Jet engines
- Laboratory research
- Nuclear environments
- Power stations and steam generators
- Rocket engines
- Turbines
- Vacuum furnaces
- Exhaust gas sensing

*Not ASTM symbols

Thermocouples

High Temperature

Materials Data

Exotic Metal Sheathed Thermocouples

The specification tables shown on the following pages outline Watlow's highly specialized line of metal sheathed thermocouple configurations. Some combinations of noble or refractory metal sheaths, high temperature insulations and compatible thermocouple conductors can withstand temperatures as high as 2315°C (4200°F); others can be used in unusually corrosive environments. Pressure, atmosphere and other process variables all affect service life and operating maximums.

Unless otherwise noted, the components listed in the tables can be combined into either compacted or uncompacted constructions.

Compacted constructions are manufactured by loading conductors and crushable ceramic insulators into the sheath. This subassembly is then drawn and/or swaged down to the required O.D., uniformly compacting the insulation around the conductors. Some combinations of materials that cannot be drawn or swaged are available only in uncompacted constructions.

Uncompacted constructions use hard fired ceramic insulators strung onto the thermocouple conductors and inserted into the sheath with minimum practical clearance. This type of "loose pack" assembly cannot be bent or formed in the field. Consult factory for special pre-bent sensors.

Thermocouples

High Temperature

High Temperature Sheath Materials

Sheath Material	Approximate Melting Point	Maximum Recommended Temperature	Environment	Available Stock Constructions inch			
				0.063	0.125	0.188	0.250
Platinum-20% Rhodium (Pt-20% Rh)	1870°C (3400°F)	1650°C (3000°F)	Oxidizing, inert, vacuum	*	*	N/A	N/A
Molybdenum (Mo)	2620°C (4750°F)	1900°C (3450°F)	Inert, vacuum, reducing	N/A	LP	LP	LP
Tantalum (Ta)	2995°C (5425°F)	2400°C (4350°F)	Inert, vacuum	C	C	*	*
Titanium (Ti)	1725°C (3135°F)	Oxidizing 315°C (600°F)	Oxidizing to 315°C (600°F), inert, vacuum	N/A	*	*	*
Alloy 600	1345°C (2470°F)	1175°C (2150°F)	Inert, vacuum, reducing, oxidizing	N/A	LP	N/A	LP

C = Compacted LP = Loose pack NA = Not available *Available as a special.

Sheath Material	Remarks
Platinum-10% Rhodium (Pt-10% Rh)	Used primarily in oxidizing environments to 1550°C (2825°F). Applications include semiconductor manufacturing, research and gas turbine probes. Silicon, sulfur and carbon are contaminants of platinum and should be avoided.
Platinum-20% Rhodium (Pt-20% Rh)	Same uses as platinum-10% rhodium; except usable to 1650°C (3000°F) with increased high temperature strength.
Molybdenum (Mo)	Molybdenum is a refractory metal that is brittle and available in uncompacted styles only. Do not use in oxidizing environments above 400°C (750°F). Vacuum at <10(-2) torr to 1700°C (3100°F). Vacuum <10(-4) torr to 1870°C (3400°F). Stable in inert gases to 1900°C (3450°F). Avoid contamination with graphite, carbon and hydrocarbons.
Tantalum (Ta)	Refractory metal that is very ductile. Use only in inert atmospheres or very good vacuums. <10(-3) torr. Hydrogen and nitrogen will react with tantalum above 400°C (750°F) resulting in nitride and hydride formation that will affect life.
Titanium (Ti)	Lightweight, excellent strength in the 150 to 425°C (300 to 800°F) temperature range. Excellent resistance to oxidizing agents such as nitric or chromic acids. Resistant to inorganic chloride solutions, chlorinated organic compounds and moist chlorine gas. Resistant to salt water spray and sea water.
Alloy 600	Maximum temperature 1175°C (2150°F). Most widely used thermocouple sheath material. Good high temperature strength, corrosion resistance, resistance to chloride ion stress corrosion cracking and oxidation resistance to high temperatures. Do not use in sulfur bearing environments. Good in nitriding environments.

Thermocouples

High Temperature

High Temperature Insulation Material

Insulation	Approximate Upper Useful Temperature	Approximate Melting Point	Remarks
Magnesium Oxide (MgO)	1370°C (2500°F)	2800°C (5070°F)	Used primarily with platinum sheathing in compacted constructions only.
Alumina Oxide (Al_2O_3)	1540°C (2800°F)	2015°C (3660°F)	Compacted constructions to 1540°C (2800°F). Uncompacted constructions with vitrified insulators to 1650°C (3000°F).
Hafnia Oxide (HfO_2)	4530°F (2500°C)	2760°C (5000°F)	Available in compacted and uncompacted constructions.

Insulation	Properties
Magnesium Oxide (MgO) (99.4% min. purity)	Low impurity levels make this insulation very useful for all thermocouple calibrations up to 1370°C (2500°F). Above 1370°C (2500°F) we recommend using beryllium oxide insulation because of MgO's low resistivity at these elevated temperatures. This material meets the requirements established in ASTM E 235.
Alumina Oxide (Al_2O_3) (99.6% min. purity)	Comparable electrical properties to MgO. Used primarily in loose pack constructions because of availability and low cost.
Hafnia Oxide (HfO_2)	Hafnia is replacing BeO in applications where BeO cannot be used because of safety concerns. Hafnia can be used up to 2500°C (4530°F).

Thermocouples

High Temperature

High Temperature Sensing Wire

Conductors	ASTM Designation	Approx. Upper Useful Temperature	Melting Point	Remarks
Pt-10% Rh vs. Pt Pt-13% Rh vs. Pt	S R	1480°C (2700°F)	1760°C (3200°F)	Some decalibration at continued use over 1095°C (2000°F) due to rhodium volatilization. This effect is accelerated in compacted construction.
Pt-30% Rh vs. Pt-6% Rh	B	1700°C (3100°F)	1790°C (3250°F)	Less subject to decalibration by rhodium volatilization than Types S or R.
W-5% Re vs. W-26% Re	C*	2315°C (4200°F)	3095°C (5600°F)	Brittle; avoid flexing.

Calibration Type	Remarks
ASTM Type R	Type R is composed of a positive leg (RP) which is 87% platinum and 13% rhodium, and a negative leg (RN) which is 100% platinum. When protected by compacted mineral insulation and appropriate outer sheath, Type R is usable from 0 to 1480°C (32 to 2700°F). Type R is available in standard limits and special limits ITS-90 scale.
ASTM Type S	Type S is composed of a positive leg (SP) which is 90% platinum and 10% rhodium, and a negative leg (SN) which is 100% platinum. When protected by compacted mineral insulation and appropriate outer sheath, Type S is usable from 0 to 1480°C (32 to 2700°F). Type S has a lower EMF output than Type R and is available in standard limits and special limits ITS-90 scale.
ASTM Type B	Type B is composed of a positive leg (BP) which is approximately 70% platinum and 30% rhodium and a negative leg (BN) which is approximately 94% platinum and 6% rhodium. When protected by compacted mineral insulation and appropriate outer sheath, Type B is usable from 870 to 1700°C (1600 to 3100°F). Type B is available in standard limits and special limits ITS-90 scale.
Type C*	Type C is composed of a positive leg (CP) which is approximately 95% tungsten, 5% rhenium and a negative leg (CN) which is approximately 74% tungsten, 26% rhenium. When protected by mineral insulation and appropriate outer sheath, Type C is usable from 0 to 2315°C (32 to 4200°F). Type C calibrations are used most often with hafnia oxide insulation and either molybdenum or tantalum sheath. These combinations can only be used in an inert or vacuum environment.

*Not an ASTM symbol

Basic Hot Or Measuring Junctions Available

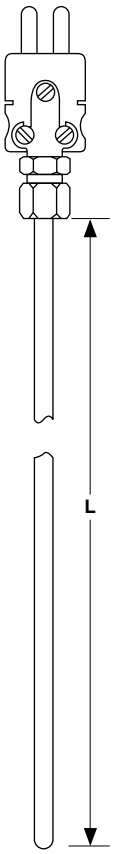
Ungrounded Junction (U)

The thermocouple junction is fully insulated from welded sheath end. Excellent for electrical applications where stray EMFs and EMIs would affect the reading and for frequent or rapid temperature cycling.

Thermocouples

High Temperature

High Temperature Plug or Jack Termination



- Features noble or refractory metal sheaths
- ASTM Type R, S, B, W-5 percent Re/W-26 percent Re (Type C*) thermocouple calibrations
- High temperature insulations
- Compacted and loose pack assemblies
- Plug or jack cold end terminations

Ordering Information—To order, complete the part number on the right with the information below:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
H	C			0								0	0	

3. Sheath O.D. (inch)

E = 0.063 H = 0.188
G = 0.125 J = 0.250

4. Connector Type

Standard plugs and jacks 205°C (400°F)
(0.250 in. max. O.D.)

A = Standard plug
B = Standard jack
C = Standard plug with mating connector

5. Enter "0"

6. Insulation

	MgO	Al_2O_3	HfO_2
** Compacted	1	2	4
Loose pack	—	B	D

7. Sheath Material

2 = Pt- 20% Rh 4 = Tantalum
3 = Molybdenum 5 = Titanium Q = Alloy 600

8-9. Sheath Length "L" (inch)

Whole inches: 01 to 60

10. Sheath Length "L" (fractional inch)

0 = 0 2 = ¼ 4 = ½ 6 = ¾
1 = ⅛ 3 = ⅜ 5 = ⅝ 7 = ⅞

11. Junction

	Ungrounded
Single	U
Dual	Consult factory

12. Calibration

	B	R	S	C*
Std. limits	B	R	S	C
Spc. limits	Consult factory			

13-14. Enter "00"

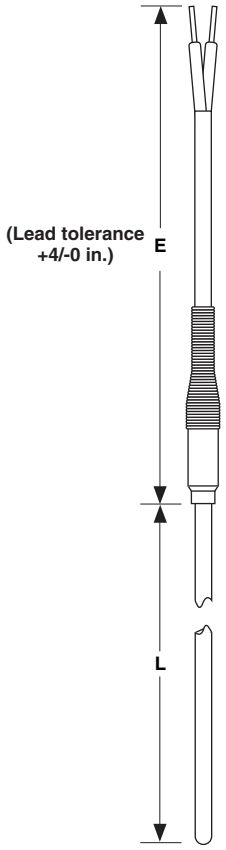
15. Special Requirements

If none, enter "0".
If required, consult factory

* Not an ASTM symbol.
** Not available with molybdenum sheath.

High Temperature

High Temperature Metal Transitions



- Features noble or refractory metal sheaths
- ASTM Type R, S, B, W-5 percent Re/W-26 percent Re (Type C*) thermocouple calibrations
- High temperature insulations
- Compacted and loose pack assemblies
- Transition with lead wire termination
- Standard maximum continuous operating temperature of 260°C (500°F) for the transition.

Ordering Information—To order, complete the part number on the right with the information below:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
H	F													

3. Sheath O.D. (inch)

E = 0.063 H = 0.188
G = 0.125 J = 0.250

4. Lead Wire Construction

	Standard	Overbraid
Fiberglass	Solid	**A**	**J**

5. Lead Wire Termination

A = Standard plug
B = Standard jack
C = Standard plug with mating connector
F = Miniature plug
G = Miniature jack
H = Miniature plug with mating connector
T = Standard—1 ½ inch split leads
U = 1 ½ inch split leads with spade lugs
W = 1 ½ inch split leads with BX connector and spade lugs

6. Insulation

	MgO	Al_2O_3	HfO_2
** Compacted	1	2	4
Loose pack	—	B	D

7. Sheath Material

2 = Pt 20% Rh 4 = Tantalum
3 = Molybdenum 5 = Titanium Q = Alloy 600

8-9. Sheath Length "L" (inch)

Whole inches: 01 to 60

10. Sheath Length "L" (fractional inch)

0 = 0 2 = ¼ 4 = ½ 6 = ¾
1 = ⅛ 3 = ⅜ 5 = ⅝ 7 = ⅞

11. Junction

	Ungrounded
Single =	U
Dual =	Consult factory

12. Calibration

	B	R	S	C*
Std. limits	B	R	S	C
Spc. limits	Consult factory			

13-14. Lead Wire Length "E" (feet)

Whole feet: 01 to 25
(01 foot standard)

15. Special Requirements

M = Standard 260°C (500°F) potting
If others required, consult factory

* Not an ASTM symbol, Consult factory for availability.
** Not available with molybdenum sheath.