Pyrotek®

Thermocouple
Quick Reference Guide

Aluminium Temperature Sensing Solutions
from the Smelter to the Foundry

why pyrotek?

Pyrotek® is a global engineering leader and innovator of technical solutions, integrated systems and consulting services for material processing industries including aluminium, cement, glass and steel.

Privately owned since 1956, Pyrotek offers industry-leading technical expertise and global resources in more than 35 countries with over 60 locations.

Pyrotek's mission is to provide innovative solutions to customer needs utilizing our global resources.

Complete thermocouple / thermocouple protection tube (TC / TCPT) assemblies and accessories

Refurbishment and vendor management services

Extensive thermocouple and industry experience

Over 25 years of thermocouple design and manufacturing combined with 70-plus years of industry experience

Thermocouples in Anode Bake

- Firing frame
- Temperature pressure ramp (TPR) and exhaust
- Isotherm

Firing Frame: Flue and Pit Thermocouples

Flue

Pit

LOCATION	TC TYPE	TCPT	AVERAGE LIFE	AVERAGE LENGTH	QUANTITY USED
FLUE	N	INCONEL® 601	4–5 months	1500 mm (59 in)	1 per flue opening
	S	Re-SiC	12 months	1400 mm (55 in)	1 per flue opening
PIT	N	310SS or 253MA	1–2 months	1450 mm (57 in)	1–4 per section
	N	INCONEL 601	4–5 months	1450 mm (57 in)	1–4 per section

INCONEL® is a registered trademark of the Special Metals Corporation group of companies.

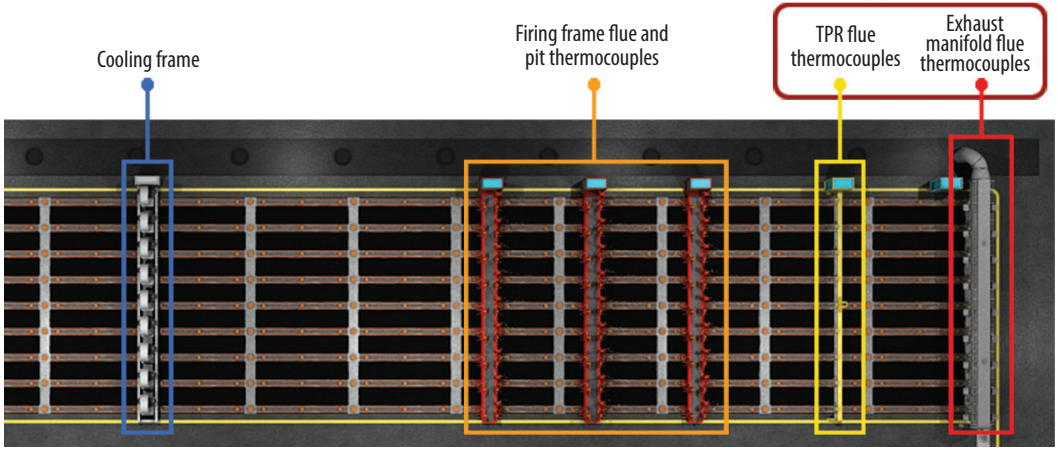
Additional Accessories: Flue port covers designed to customer's specifications. Consult with a Pyrotek sales engineer.

Flue and Pit Thermocouples—Pyrotek Models

I2 Series: Base metal elements protection tube style

P4 Series: Thermocouple extensions

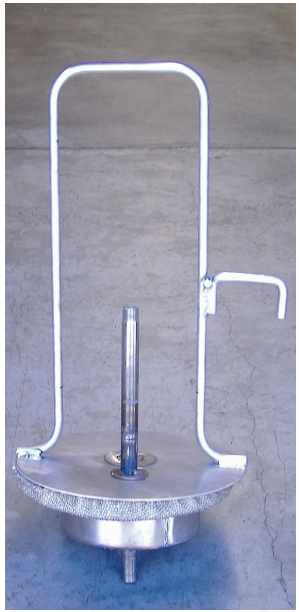
Temperature Pressure Ramp and Exhaust



LOCATION	TC TYPE	TCPT	AVERAGE LIFE	AVERAGE LENGTH	QUANTITY USED
PREHEAT AREA TPR DRAFT CONTROLLER	K	INCONEL or 310SS or 253MA	2–5 months	1100 mm (43 in)	1 per flue section
EXHAUST MANIFOLD	K	Not required	2–4 months	300 mm (12 in)	As low as 1 manifold

Temperature Pressure Ramp and Exhaust

Custom covers include handle and access points for measuring temperature and pressure



Temperature Pressure Ramp and Exhaust Pyrotek Models

I2 Series: Base metal elements protection tube style

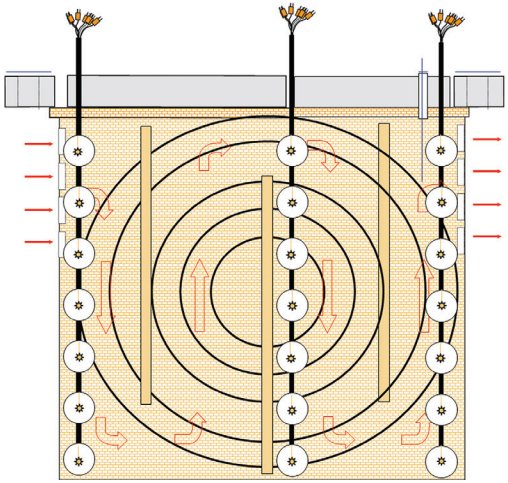
M2 Series: Mineral insulated elements with plug or jack style

M3 Series: Mineral insulated elements head and block style

Measuring Heat Distribution—Isotherm

- Contour temperature mapping
- Bundle of thermocouples made to varying lengths, used to determine pit head distribution
- Seven thermocouples of various lengths
- At the centre of the pit section

LOCATION	TC TYPE	TCPT	AVERAGE LIFE	AVERAGE LENGTH
PIT	K	Cast Iron	Single Use	Varies



Measuring Heat Distribution—Pyrotek Models

I9 Series: Cast iron and enameled cast iron style

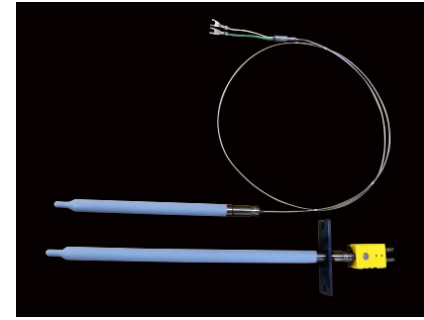
M2 Series: Mineral insulated elements with plug or jack style

Thermocouples in Electrolysis Pots

Thermocouples in Electrolysis Pots

- Temperature check during start-up
- Profiling cathode surface temperature
- Temperature is taken daily or every second day on every pot

LOCATION	TC TYPE	AVERAGE LIFE	AVERAGE LENGTH
MOLTEN ELECTROLYTE BATH	K Heavy wall minimum 5.5 mm (3/16 in) outer diameter	Disposable or repeating use with repair	Starting length at 1500 mm (59 in)
	Quick Tips		Starting length at 203 mm (8 in)

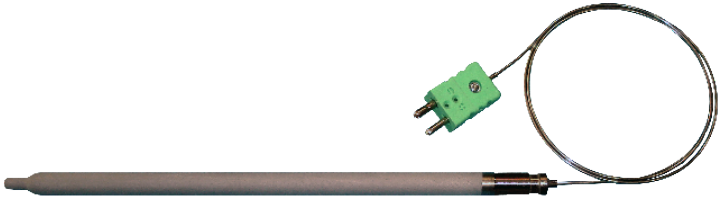


Thermocouples in Electrolysis Pots—Pyrotek Models

M2 Series: Mineral insulated elements with plug or jack style

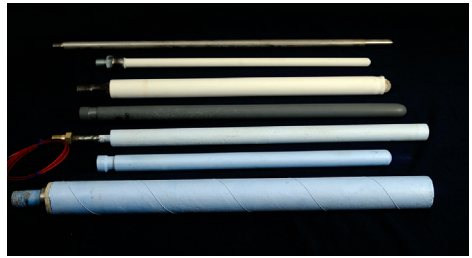
M4 Series: Mineral insulated thermocouples with lead wire

Quick Tip Series: Quick response sampling thermocouples



Pyrotek Thermocouple Protection Tubes

- Cast iron
- O'-Sialon
- Sialon B100
- Pinnacle
- Reinforced fibreglass material (RFM®)
- Other



Thermocouples in Casthouse Furnaces

Casthouse Furnace—Metal Immersion

PRODUCT COMPARISON					
*THERMOCOUPLE PROTECTION TUBE	APPLICATION	MECHANICAL STRENGTH	LIFE EXPECTANCY (Proper maintenance and care)	WORKING TEMPERATURE	PYROTEK MODELS
CAST IRON PLAIN / CAST IRON ENAMEL Both withstand the rigors of furnace environment. Their physical strength is ideal for casthouse handling. Ceramic-coated tubes provide 25–50% longer life than plain cast iron tubes.	• Reverb melting furnaces • Degassing • Holding furnaces	Cast iron strong	1–2 weeks**	800°C (1472°F)	I9 Series T2 Series
PINNACLE The unique properties of Pinnacle thermocouple tubes provide long life, are non-wetting and ideal for temperature-sensitive applications.	• Reverb melting furnaces • Degassing • Holding furnaces	Refractory with steel pipe reinforced	3–6 months	1100°C (2012°F)	I5 Series I6 Series T1 Series
RFM Non-wetting to aluminium and its alloys. Reinforced material coupled with an internal steel tube has the ability to withstand mechanical abuse.	• Degassing • Holding furnaces • Troughs	Composite refractory with steel pipe reinforced	3–6 months	800°C (1472°F)	I5 Series I6 Series T1 Series

*Always consult with a Pyrotek sales engineer to properly define the TCPT solution for your application.

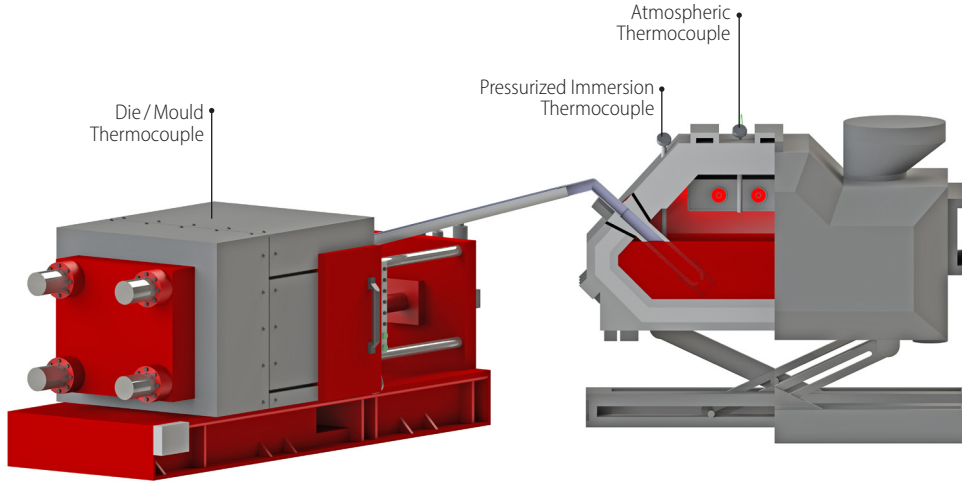
** Longer with insertion/extraction mechanical systems.

Casthouse Furnace—Atmospheric

PRODUCT COMPARISON					
*THERMOCOUPLE PROTECTION TUBE	APPLICATION	MECHANICAL STRENGTH	LIFE EXPECTANCY (Proper maintenance and care)	WORKING TEMPERATURE	PYROTEK MODELS
INCONEL 601 Well known and standard material with great resistance to heat and corrosion. It is not intended for direct immersion in molten metal.	• Preheat section and pit / flue firing chambers in anode bake • Roof furnaces • Heat treatment	Stainless steel strong	7–9 months	1260°C (2300°F)	I2 Series I3 Series IP Series
ALUMINA Roof furnace free air application in the heat treatment, glass and ferrous metal industries.	• Roof furnaces • Heat treatment	Alumina ceramic	3–5 months	1600°C (2912°F)	I4 Series
MULLITE Another option for roof furnace free air applications with a lower temperature rating than alumina tubes.	• Roof furnaces • Heat treatment	Mullite ceramic	3–5 months	1400°C (2552°F)	I4 Series

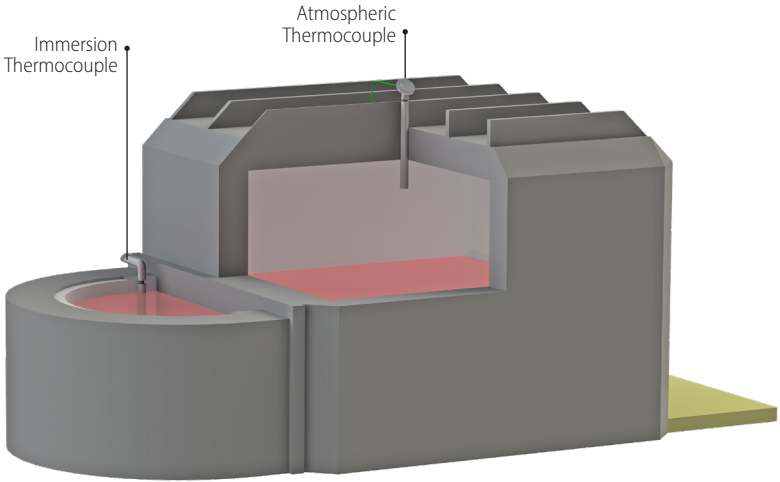
*Always consult with a Pyrotek sales engineer to properly define the TCPT solution for your application.

Thermocouples in High-Pressure Die Casting Dosing Furnace



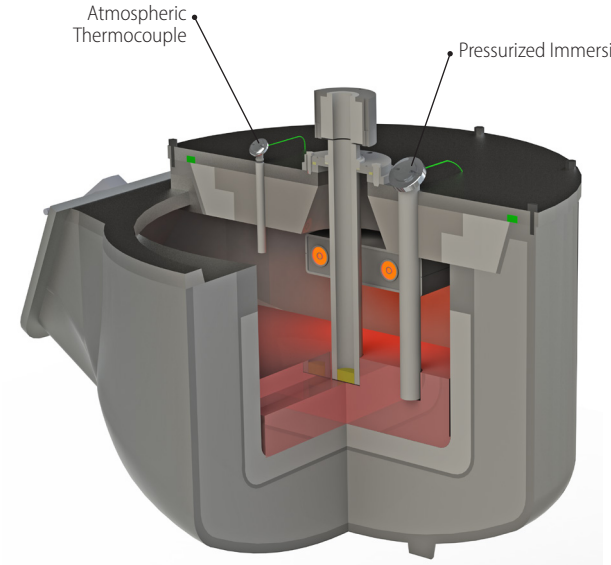
Additional thermocouples: sampling, extensions, wires and accessories

Thermocouples in Gravity Permanent and Semi-permanent Mould Sand Casting



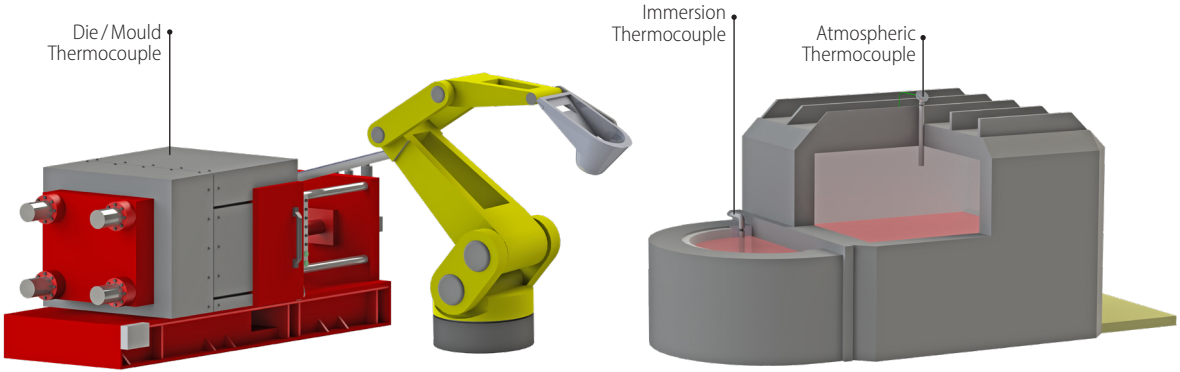
Additional thermocouples: die / mould, sampling, extensions, wires and accessories

Thermocouples in Low-Pressure Die Casting



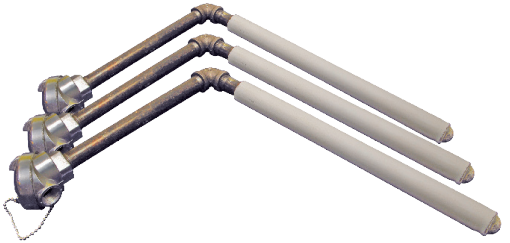
Additional thermocouples: die / mould, sampling, extensions, wires and accessories

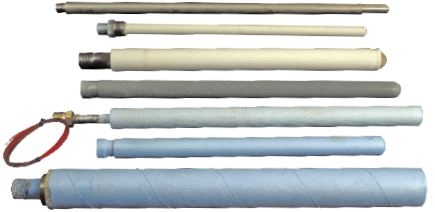
Thermocouples in High-Pressure Die Casting and Robotic AutoPour



Additional thermocouples: sampling, extensions, wires and accessories

Immersion Thermocouples — Various TCPT Assemblies



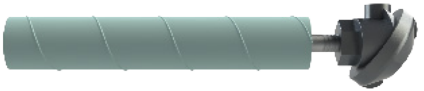


Molten Metal Immersion Series

*TCPT TYPE	RATED OPERATING TEMPERATURE	IMAGE	RELATIVE RESPONSE LIFE (#1 Fastest)	RELATIVE SERVICE LIFE	PYROTEK MODELS
RFM	800°C (1472°F)		#3	3–6 Months	I5 Series I6 Series
Sialon B100 / SiN	1100°C (2012°F)		#1	10–13 Months	I7 Series I8 Series
O'-Sialon	1100°C (2012°F)		#1	2–4 Months	

*Always consult with a Pyrotek sales engineer to properly define the TCPT solution for your application.

Molten Metal Immersion Pressurized Vessel Series

*TCPT TYPE	RATED OPERATING TEMPERATURE	IMAGE	RELATIVE RESPONSE LIFE (#1 Fastest)	RELATIVE SERVICE LIFE	PYROTEK MODELS
Pinnacle	1100°C (2012°F)		#2	3–6 Months	I5 Series I6 Series
Sialon B100 / SiN	1100°C (2012°F)		#1	10–13 Months	I7 Series I8 Series
O'-Sialon	1100°C (2012°F)		#1	2–4 Months	

*Always consult with a Pyrotek sales engineer to properly define the TCPT solution for your application.

Atmospheric Thermocouples

Protection tube selection

Thermocouples

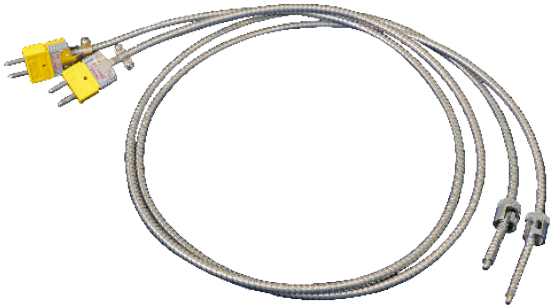
Atmospheric Thermocouples Series

*TCPT Type	RATED OPERATING TEMPERATURE	TYPE OF ATMOSPHERIC APPLICATIONS	RELATIVE SERVICE LIFE	PYROTEK MODELS
INCONEL 601	1260°C (2300°F)	• Roof furnace • Heat treat • Open anode bake furnace: preheat section and pit/flue firing chambers	7–9 Months	I2 Series
Alumina	1600°C (2912°F)	• Roof furnace • Heat treat	>12 Months	I4 Series
Mullite	1400°C (2552°F)	• Roof furnace • Heat treat		

*Always consult with a Pyrotek sales engineer to properly define the TCPT solution for your application.

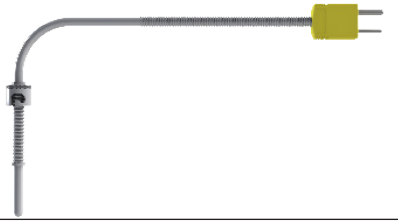
Die / Mould Thermocouples

Thermocouple with compression bayonet adapter



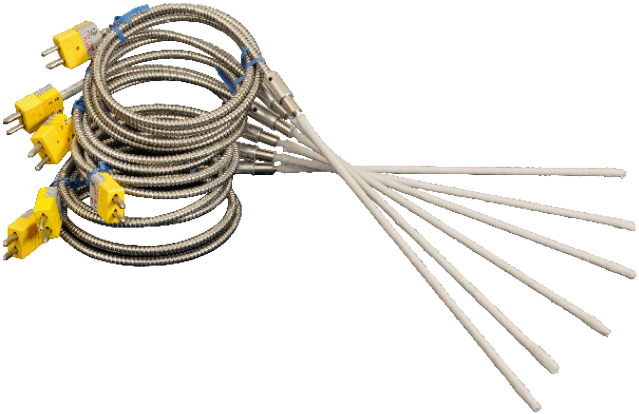
Thermocouple with bayonet adapter and armour

Die / Mould Thermocouple Series

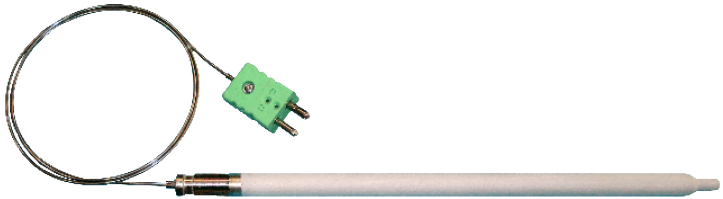
*TYPE	IMAGE	PYROTEK MODELS
90° angle with compression fitting or bayonet adapter		P1 series
Spring adjustable with bayonet adapter		P2 series
Armour adjustable with bayonet adapter		P3 series
MgO with extension wire		M4 series

*Always consult with a Pyrotek sales engineer to properly define the correct mould thermocouple. Replace thermocouples at every mould/die maintenance change out.

Sampling Thermocouples for Quick Temperature Measurements



Coated MgO sampling thermocouple



Quick tip sampling thermocouple

Sampling Thermocouple Series

*TYPE	IMAGE	PYROTEK MODELS
Quick tip		QuickTip series
MgO or MI		M2 series M4 series
Coated MgO		
Sleeve and coated MgO		

*Always consult with a Pyrotek sales engineer to properly define the correct sampling thermocouple. Magnesium Oxide (MgO) or Mineral Insulated (MI).

Thermocouple Intelligence Mining

Present situation

- What type of thermocouple and thermocouple protection tube are currently being used?
- Type of thermocouple junction used?
- Extension leads, fixed to or separate from the thermocouple assembly?
- Are there refurbish or recycle programs in place?
- What are current pains, problems, shortcomings?

Application and position or installation situation

- What is the application?
- Do the thermocouple and thermocouple protection tube require special fixtures?
- Are solids charged close to the thermocouple location?
- Is there vibration present during normal operation?
- Is there electrical interference?

Thermocouple Wire Types

THERMOCOUPLE TYPE	WIRE METAL		SUITABLE	CONCERNS
	+	–		
TYPE J BASE METALS	Iron, magnetic response	Constantan nickel 45% copper	• Suitable in vacuum, air, reducing or oxidizing atmospheres to 760°C (1400°F) • Mainly used in plastic applications • Used for annealing and homogenizing furnaces	• Should not be used in sulfurous atmospheres above 540°C (1000°F)
TYPE K BASE METALS	Chromel, 10% chromium	Alumel magnetic response	• Traditional base metal choice in the aluminium industry • Performs best in clean oxidizing or inert atmospheres, up to 1260°C (2300°F)	• Must not be exposed to sulfur-containing atmospheres
TYPE N BASE METALS	Nicrosil	Nisil	• Performs best in clean oxidizing or inert atmospheres, up to 1260°C (2300°F) • Less calibration drift than type K when used in temperatures above 1000°C (1800°F)	• Must not be used in vacuum or reducing atmospheres • Non-magnetic wires
TYPE S NOBLE METALS	Platinum, 10% rhodium	Platinum	• Best for continuous inert atmospheres, up to 1480°C (2700°F)	• At continuous use in 1100°C (2000°F), wires must be protected from exposure to metallic and nonmetallic vapor

Thermocouple Wire—Base Metal (Industrial) Element

- No sheath protection
- Ceramic bead insulation
- Unprotected hot junction
- Susceptible to green rot

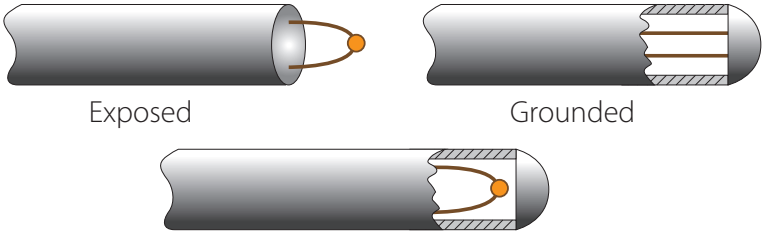
Butt weld

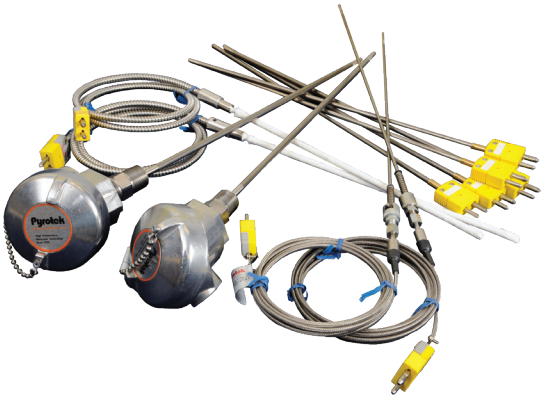
Twisted weld

Thermocouple Wire—Mineral Insulate (MI) or Magnesium Oxide (MgO) Element

- Ability to withstand corrosive environment
- Magnesium oxide (MgO) insulated
- Hot junction is protected
- Long service life compared to industrial wire
- Formable

JUNCTION TYPES





Mineral Insulated Thermocouple Sheath

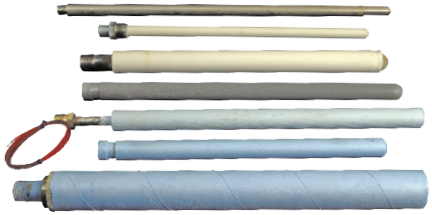
MATERIAL	MAXIMUM OPERATING TEMPERATURE	BENEFIT / WIDELY USED IN
304 SS	900°C (1650°F)	• Most common low temperatures • Holding and melting furnaces with protection tube
321 SS	870°C (1600°F)	• Better corrosion resistance than 304 stainless steel • Better resistance in environments where carbide precipitation is a concern
316 SS	900°C (1650°F)	• Best corrosion resistance over 304 stainless steel • Holding and melting furnaces with protection tube
310 SS	1150°C (2100°F)	• Better mechanical and corrosion resistance at higher temperatures • Anode bake pit, melting furnace with protection tube
446 SS	1150°C (2100°F)	• Resistance to sulfurous atmospheres • Commonly used in steel and cement industry
Alloy 600	1175°C (2150°F)	• Oxidation resistance • Anode bake flue

Thermocouple Wire Tolerance

THERMOCOUPLE TYPE	STANDARD REFERENCE	CLASS 1/SPECIAL LIMITS	TOLERANCE	CLASS 2/STANDARD LIMITS	TOLERANCE
TYPE K	IEC-EN 60584-2	-40 to 375°C	±1.5°C	-40 to +333°C	±2.5°C
		375 to 1200°C	0.4% of reading	333 to 1200°C	0.75% of reading
	ASTM E230-ANSI MC96.1	0 to 750°C	±1.1°C-or 0.4% of reading	0 - 750	±2.2°C or 0.75% of reading
TYPE N	IEC-EN 60584-2	-40 to 375°C	±1.5°C	-40 to +333°C	±2.5°C
		375 to 1200°C	0.4% of reading	333 to 1200°C	0.75% of reading
	ASTM E230-ANSI MC96.1	0 to 900°C	±1°C-or 0.4% of reading	0 to 900°C	±1.7°C or 0.5% of reading
TYPE R/S	IEC-EN 60584-2	0 to 1100°C	±1.°C	-0 to 600°C	±1.5°C
		1100 to 1600°C	±[1+0.003(t-1100)]	333 to 800°C	0.25% of reading
	ASTM E230-ANSI MC96.1	0 to 1450°C	±0.6° or 0.1% of reading	0 to 1450°C	±1.5° or 0.25% of reading

Pyrotek Thermocouple Protection Tubes

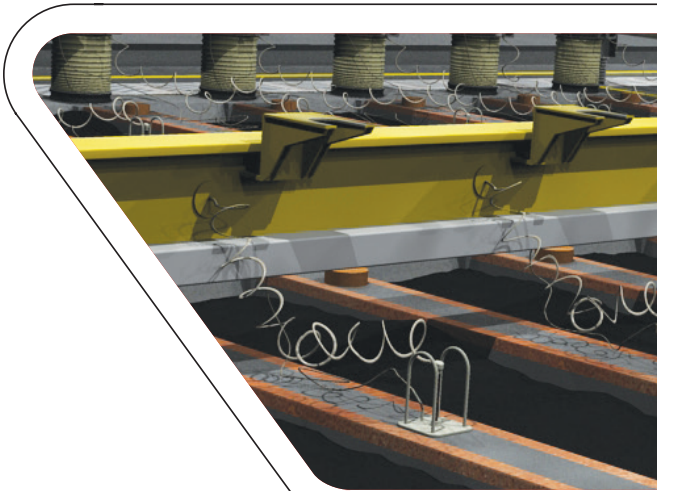
- Cast iron
- O'-Sialon
- Sialon B100
- Pinnacle
- RFM and more



°C	°F	°C	°F	°C	°F	°C	°F	°C	°F
-273	-459.4	-17.2	1	16.1	61	149	300	482	900
-268	-450	-16.7	2	16.7	62	154	310	488	910
-262	-440	-16.1	3	17.2	63	160	320	493	920
-257	-430	-15.6	4	17.8	64	166	330	499	930
-251	-420	-15.0	5	18.3	65	171	340	504	940
-264	-410	-14.4	6	18.9	66	177	350	510	950
-240	-400	-13.9	7	19.4	67	182	360	516	960
-234	-390	-13.3	8	20.0	68	188	370	521	970
-229	-380	-12.8	9	20.6	69	193	380	527	980
-223	-370	-12.2	10	21.2	70	199	390	532	990
-218	-360	-11.7	11	21.7	71	204	400	538	1000
-212	-350	-11.1	12	22.2	72	210	410	549	1020
-207	-340	-10.6	13	22.8	73	216	420	560	1040
-201	-330	-10.0	14	23.3	74	221	430	571	1060
-196	-320	-9.4	15	23.9	75	227	440	582	1080
-190	-310	-8.9	16	24.4	76	232	450	593	1100
-184	-300	-8.3	17	25.0	77	238	460	604	1120
-179	-290	-7.8	18	25.6	78	243	470	616	1140

Inch Fraction	Inch Decimal	Millimeter	Inch Fraction	Inch Decimal	Millimeter
1/64	0.0156	.3962	33/64	0.5156	13.0962
1/32	0.0313	.7950	17/32	0.5313	13.4950
3/64	0.0469	1.1913	35/64	0.5469	13.8913
1/16	0.0625	1.5875	9/16	0.5625	14.2875
5/64	0.0781	1.9837	37/64	0.5781	14.6837
3/32	0.0938	2.3825	19/32	0.5938	15.0825
7/64	0.1094	2.7788	39/64	0.6094	15.4788
1/8	0.1250	3.1750	5/8	0.6250	15.8750
9/64	0.1406	3.5712	41/64	0.6406	16.2712
5/32	0.1563	3.9700	21/32	0.6563	16.6700
11/64	0.1719	4.3663	43/64	0.6719	17.0663
3/16	0.1875	4.7625	11/16	0.6875	17.4625
13/64	0.2031	5.1587	45/64	0.7031	17.8587
7/32	0.2188	5.5575	23/32	0.7188	18.2575
15/64	0.2344	5.9538	47/64	0.7344	18.6538
1/4	0.2500	6.3500	3/4	0.7500	19.0500
17/64	0.2656	6.7462	49/64	0.7656	19.4462
9/32	0.2813	7.1450	25/32	0.7813	19.8450
19/64	0.2969	7.5413	51/64	0.7969	20.2413
15/16	0.3125	7.9375	13/16	0.8125	20.6375
21/64	0.381	8.3337	53/64	0.8281	21.0337
11.32	0.3438	8.7325	27/32	0.8438	21.4325
23/64	0.3594	9.1288	55/64	0.8594	21.8288
3/8	0.3750	9.5250	7/8	0.8750	22.2250
25/64	0.3906	9.9212	57/64	0.8906	22.6212
13/32	0.4063	10.3200	29/32	0.9063	23.0200
27/64	0.4219	10.7163	59/64	0.9219	23.4163
7/16	0.4375	11.1125	15/16	0.9375	23.8125
29/64	0.4531	11.5087	61/64	0.9531	24.2087
15/32	0.4688	11.9075	31/32	0.9688	24.6075
31/64	0.4844	12.3038	63/64	0.9844	25.0038
1/2	0.5000	12.7000	1	1.0000	25.4000

Pyrotek®



pyrotek.com/thermocouples

Sep-25-EN-1416