Overview

Introduction

Several methods of temperature measurement and control have been developed over the years. Industrial process control usually requires that the temperature sensing device must be remote from the measuring or controlling instrument. Of the various thermal sensing devices, the thermocouple is most commonly used, offering the best compromise of cost, accuracy and reliability.

We are a leading manufacturer of thermocouples. Our modern production facilities and years of experience allow us to provide the highest quality sensors at competitive prices.

Warning

> Hazardous extraneous voltage capable of causing severe injury or death may exist between thermocouple leads and ground. Disconnecting the instrument power may not remove this voltage. Measure for the presence of voltage between each sensor lead and ground before servicing.

Thermocouple Assemblies

A thermocouple assembly generally has four major components:

Element Two wires of dissimilar alloys joined at the tip. When the ends are exposed to a temperature gradient, and electromotive force (EMF) is generated. The EMF is very small, amounting to microvolts per degree.

Protection Tube A metal or ceramic tube, usually closed at the end, that protects the element from the environment of the process.

Head or Cold End Termination The head is a terminal block/protective enclosure assembly provided for connection to thermocouple extension wire. In lieu of this, an integrated extension assembly may be provided.

Extension Wire Although not a portion of the thermocouple assembly itself, the extension wire is a critical part of the total circuit. The wire must be manufactured from alloys compatible with the element.

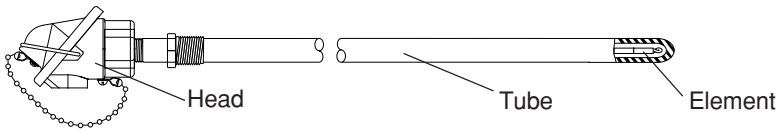
In addition, various mounting devices or attaching devices are offered for most assemblies.

Construction Styles

Thermocouples have been manufactured in endless combinations of construction. While no supplier can meet 100% of all customer requirements, we offer one of the widest varieties of thermocouple assemblies in the industry.

Three styles of construction dominate: Tube and Element, BARCOPAC® and Bayonet.

Tube and Element



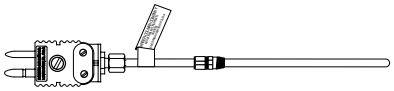
The protection tube, head and element are discrete components. The element is manufactured with individual conductors welded together at the tip. Element wires are separated by ceramic insulators. The protection tube can be thin wall tubing, schedule 40 pipe, ceramic or cast iron. Cold end termination is usually with a head and terminal block assembly.

Noble metal thermocouples are often supplied with two or more protection tubes. The tube in contact with the element must be ceramic; the outer tube can be either ceramic or metal.

Overview

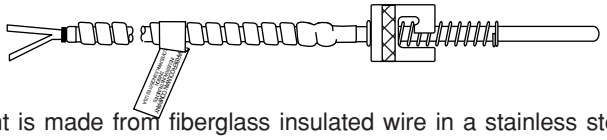
Construction Styles (continued)

BARCOPAC®



BARCOPAC® is the trade name for our magnesium-oxide (MgO) insulated thermocouples. This style consists of element conductors in magnesium oxide insulation with a stainless steel or Inconel sheath. The assembly is then drawn to the finish diameter. This form of construction compacts the insulation around the conductors. The result is a thermocouple with superior performance and longevity. The material can be bent to nearly any desired shape without damaging the element. Diameters of 0.040" to 0.250" are available.

Bayonet



The element is made from fiberglass insulated wire in a stainless steel protection tube. Usually the element is brazed to the tube at the tip. Mounting is with a twist-lock fitting commonly referred as a bayonet adapter. This form of construction is sometimes known as a "plastic style" because of its heavy usage in the plastics industry.

Alloy Selection

A thermocouple element consists of two wires of dissimilar alloys joined at the tip. When the ends of the elements are exposed to a temperature difference, an EMF is generated along the entire length of the element. The EMF level is dependent on the amount of temperature difference and the type of alloys used.

Alloy combinations have been developed to meet specific requirements. Each alloy set has certain characteristics (cost, temperature range, corrosion, resistance, etc.) that provide advantages for specific applications.

To simplify selection and provide uniformity, several alloy combinations have had single letter codes assigned by ANSI (American National Standards Institute) to designate particular types of thermocouples. For example, Type J for Iron vs. Constantan, Type K for Chromel vs. Alumel, and Type R for Platinum vs. Platinum/13% Rhodium.

Each alloy set has a unique EMF output for a given temperature. The measuring instrument is calibrated for a specific type thermocouple. When specifying replacement thermocouples, the element is typically the same type as the original.

Elements are classified into three groups: Base Metal, Noble Metal and Refractory Metal.

Elements, Base Metal

Main advantages are economical cost, good reliability and reasonable accuracy. Use primarily for low to moderately high temperature range (-200° to 1700°C). Over 90% of all thermocouples are in this group. Types J and K prevail.

Type E, Chromel vs. Constantan
Suitable for use from -200 to 871°C. Can be applied in atmospheres ranging from vacuum to mildly oxidizing. Excellent choice for cryogenic applications. Has the highest EMF per degree of all the common elements.

Type J, Iron vs. Constantan

Alloy Selection (continued)

The standard selection for use from 0° to 600°C. Type J has good reliability at lower temperatures. The positive leg will oxidize rapidly above 500°C. Very economical. Used extensively in the plastics industry but applicable to almost any process within its operating range. Available in a wide variety of construction styles.

Type K, Chromel vs. Alumel
Type K is the industry standard for use up to 1250°C. While stable in oxidizing atmospheres, it is prone to corrosion in reducing environments. Protection tubes are always recommended.

Type N, Nicrosil vs. Nisil
Similar to Type K but more resistant to oxidation and less subject to large drift in the EMF that is found in the positive Type K thermocouples operating at approximately 500°C.

Type T, Copper vs. Constantan
Suitable for use from -200° to 350°C, Type T is widely used in the food processing industry. More stable than Types E or J for low temperature applications. Has been used down to -269°C (boiling helium).

Elements, Noble Metal

Elements manufactured from noble metals offer improved accuracy and stability over base metals. Most are manufactured from combinations of Platinum and Rhodium. Commonly used in high temperature applications up to 1700°C. Also applied as reference standard when testing base metal elements. Highest cost of all thermocouples.

Type R, Platinum vs. Platinum/13% Rhodium
Type R has long been the industrial standard noble metal alloy used for high temperature applications to 1450°C. Platinum is prone to contamination if in contact with other metals. Ceramic protection tubes must be used. Very stable in an oxidizing atmosphere but will degrade rapidly in vacuum or a reducing atmosphere.

Type S, Platinum vs. Platinum/13% Rhodium
Applications and conditions similar to Type R. Type S was applied as the “laboratory thermocouple” while Type R was considered the “industrial thermocouple.” This practice was based on tradition. Type S is not being used extensively as an industrial sensor.

Type B, Platinum/6% Rhodium vs. Platinum/30% Rhodium
Applications and considerations similar to Types R and S, but useful to 1700°C. Very low output at low temperature. Also very non-linear at low end. Generally not considered usable below 250°C. More stable than R or S at high temperature. Must be protected in ceramic tube.

Elements Refractory Metal

Combinations of Tungsten and Rhenium. Very brittle and prone to breakage. Used for very high temperature applications up to 2300°C. Must be used in vacuum or totally inert atmosphere.

Type C, Tungsten/5% Rhenium vs. Tungsten/26% Rhenium
May be used at temperatures up to 2315°C. Brittle and prone to breakage. Generally considered a limited life product. Element must not be in contact with metal. Tungsten has no oxidation resistance. These elements must be used in vacuum, hydrogen or totally inert gas. Sometimes supplied with open end protection tube for use with vacuum. Otherwise manufactured as a sealed assembly purged with argon.

Selecting the Element

When selecting the proper element for an application, consideration must be given to length of service, temperature, atmosphere, response time, and cost. Be certain the Type (J, K, R, S, T, etc.) matches the instrument with which it will be used.

Overview

Limits of Error

ANSI Limits, Base Metal
Reference Junction 0°C (32°F)
Published in ANSI Circular MC96.1–1975

Type	Temperature Range	Standard	Special
J	0° to 293°C (32° to 559°F)	±2.2°C (±4°F)	±1.1°C (±2°F)
	293° to 760°C (559° to 1400°F)	±0.75%	±0.4%
K or N	-200° to -110°C (-328 to -166°F)	±2%*	**
	-110° to 0°C (-166° to 32°F)	±2.2°C (±4°F)*	**
	0° to 293°C (32° to 559°F)	±2.2°C (±4°F)*	±1.1°C (±2°F)
	293° to 1250°C (559° to 2282°F)	±0.75%	±0.4%
T	-200° to -67°C (-328° to -89°F)	±1.5%*	**
	-67° to 0°C (-89° to 32°F)	±1°C (±1.8°F)*	**
	0° to 133°C (32° to 271°F)	±1°C (±1.85°F)	±0.5°C (±0.9°F)
	133° to 350°C (271° to 662°F)	±0.75%	±0.4%
E	-200° to -170°C (-328° to -274°F)	±1%*	**
	-170° to 0°C (-274° to 32°F)	±1.7°C (±3.1°F)*	**
	0° to 340°C (32° to 644°F)	±1.7°C (±3.1°F)	±1°C (±1.8°F)
	340° to 900°C (644° to 1652°F)	±0.5%	±0.4%

*Thermocouples and thermocouple materials are supplied to meet the limits of error specified for temperatures above 0°C. A thermocouple material may not conform to the published sub-zero limits of error for that material when purchased, unless conformance is agreed to between purchaser and supplier upon placement of order.

**Special limits of error for sub-zero temperatures have not been established. The following limits for Types E and T are useful to start discussion: 200° to 0°C – Type E: ±1°C or ±0.5%, whichever is greater; Type T – ±0.5°C or ±0.8%, whichever is greater. Sub-zero limits of error for Type J and sup-zero limits of error for Type K are not considered because of the characteristics of their materials.

ANSI Limits, Noble Metal
Reference Junction 0°C (32°F)
Published in ANSI Circular MC96.1–1982

Type	Temperature Range	Standard (Greater of:)	Special (Greater of:)
B	870 to 1700°C 1598 to 3092°F	±0.5%	- -
R or S	0 to 1450°C 32 to 2642°F	±1.5°C or ±0.25%	±0.6°C or ±0.1%

In this table, the limits of error for each type of thermocouple apply only over the temperature range for which the wire size in question is recommended. These limits of error should be applied only to standard wire sizes. The same limits may not be obtainable in special sizes.

Limits of error apply to thermocouples as supplied by the manufacturer. The calibration of a thermocouple may change during use. The magnitude of the change depends on such factors as temperature, length of time, and conditions under which it was used.

Non-ANSI Limits, Refractory Metal

Type	Temperature Range		Limits of Error	
W-W, 26% Re	0 to 427°C	32 to 800°F	±4.4°C	±8°F
	427 to 2316°C	800 to 4200°F	±1%	±1%
W, 5% Re-W, 26% Re	0 to 427°C	32 to 800°F	±4.4°C	±8°F
	427 to 2316°C	800 to 4200°F	±1%	±1%
W, 3% Re-W, 25% Re	0 to 427°C	32 to 800°F	±4.4°C	±8°F
	427 to 2316°C	800 to 4200°F	±1%	±1%

Element Temperature Limits

The following table shows the allowable temperature limits for commonly used thermocouples and RTDs. These limits apply to thermocouples in conventional closed end protection tubes. In any general recommendations of temperature elements, it is not practicable to take into account special cases. In actual operation there may be instances where the temperature limits recommended can be exceeded. Likewise, there may be applications where satisfactory life will not be obtained at the recommended temperature limits. However, in general, the temperature limits listed are such as to provide satisfactory element life when the wires are operated continuously at these temperatures.

Type	Gauge	°F Range	°C Range
J	8	-70 to 1400	-57 to 760
	14	-70 to 1100	-57 to 593
	20	-70 to 900	-57 to 482
	24	-70 to 700	-57 to 371
K or N	8	-70 to 2300	-57 to 1260
	14	-70 to 2000	-57 to 1093
	20	-70 to 1800	-57 to 982
	24	-70 to 1600	-57 to 870
T	14	-70 to 700	-57 to 371
	20	-70 to 500	-57 to 260
	24	-70 to 400	-57 to 200
E	8	-70 to 1600	-57 to 871
	14	-70 to 1200	-57 to 649
	20	-70 to 1000	-57 to 538
R or S	24	-50 to 2650	-46 to 1454
B	24	32 to 2650	-0 to 1454
0.00385 Platinum RTD		-70 to 450	-57 to 232
0.00391 Platinum RTD		-70 to 450	-57 to 232

Extension Wire

A common misconception is that the EMF is generated at the tip. The voltage is actually produced along the entire length of the element and is proportional to the temperature gradient from one end to the other. One end of the element is the junction at the hot end. The other end (cold junction) of the thermocouple is at the measuring/control instrument.

The extension wire between the measuring instrument and the thermocouple assembly is part of the thermocouple circuit. It will supply a portion of the EMF generated.

The extension wire must be compatible with the alloys used in the thermocouple. For base metal thermocouples the extension wire is usually constructed of the same alloys as the element. For noble metal elements, base metal alloys are selected to match the characteristics of the element within the operating range of 0° to 150°C.

Two types of wire are available: thermocouple grade and extension grade. Thermocouple grade wire is manufactured with alloys identical to the wire use for elements. Extension grade wire for base metal thermocouples is made with similar EMF properties at ambient

Extension Wire (continued)

temperature, but is not rated for accuracy at high temperature.

Insulation is the largest factor determining performance of extension wire. Moisture resistance, abrasion resistance, temperature rating and cost are factors to be considered.

PVC has excellent moisture and abrasion resistance but is only rated to 105°C. Its low cost makes it a good choice for many applications.

Teflon and Kapton are alternatives to PVC when higher temperatures are encountered. Ratings as high as 315°C are available.

Fiberglass braided insulations have less moisture resistance, but temperature ratings up to 700°C are available.

Ceramic and Silica fiber have the highest temperature ranges but abrasion and moisture resistance are poor. Ceramic insulation rated at 1430°C is often used for furnace survey thermocouples.

ANSI Limits of Error

For extension wire

Type	Temperature Range	Standard
BX	0 to 100°C (32 to 200°F)	+0.0, -3.7°C (+0.0, -6.7°F)
SX & RX	0 to 200°C (34 to 400°F)	5.0°C (9.0°F)

Protection Tubes

Protection tubes are necessary to protect the element from contamination and physical damage. Size, shape and material vary with the application. Choices vary with the style of construction.

Bayonet style thermocouples are only available with stainless steel sheaths. This material has the durability required for the limited range of conditions encountered.

BARCOPAC® thermocouples are offered in a variety of stainless steel alloys plus Inconel. Stainless steel has excellent resistance to corrosion but is limited to applications below 870°C.

Inconel has a high nickel content and is the preferred choice for applications to 1140°C. Typically, Type J assemblies are manufactured with stainless steel, and Type K uses Inconel.

Countless combinations of assemblies manufactured from discrete element and protection tubes exist. We offer a selection of styles designed to meet the requirements of a broad range of applications. Protection tubes are available in metallic and non-metallic materials. The selection of material is dependent on the environment of the process. Generally, the larger diameter tubes offer better physical strength and longevity. They can also accommodate heavier gauge elements. The benefit of larger tubes must be weighed against the added cost of the material. In some cases, limited life material may be more cost effective than premium grade assemblies.

Metal

Low alloy material (black iron or welded steel pipe) is a good selection for application to non-corrosive environments. Advantages include low cost, excellent abrasion resistance and good physical strength. Deteriorates above 550°C in oxidizing atmosphere. Available in a variety of sizes.

Protection Tubes (continued)

Stainless steel offers improved resistance to corrosion over welded steel pipe. It has good strength and stability to 870°C (446 SS is rated to 1100°C). Available in a variety of alloys and sizes. Cost varies from moderate to high depending on specific alloy selected.

Inconel is the choice for application in highly reducing atmospheres operating at higher temperatures than stainless steel. Has excellent strength and resistance to corrosion up to 1150°C. We offer alloy 601 which has superior characteristics than commonly used alloy 600. Cost is higher than most stainless steels. Available in 1/2" or 3/4" NPT schedule 40 pipe. Inconel 600 thin wall tubing is also available.

Ceramic

Ceramics can tolerate high temperatures than any metal pipe. They can often withstand corrosive environments too extreme for the best stainless alloys. All ceramics lack the resilience of metal and are prone to breakage.

Mullite, also know as porcelain, is a good choice for base metal thermocouples. Advantages include moderate cost, good thermal conductivity and good resistance to thermal shock. Has less physical strength than alumina. Recommended for use below 1450°C.

Alumina has greater strength than Mullite and can be applied at higher temperatures. Use is typically restricted to noble metal thermocouples though it may be applied to base metal because of its corrosion resistance. Has less resistance to thermal shock than Mullite.

Silicon Carbide offers greater corrosion resistance than any commonly offered metal or ceramic material. Excellent thermal conductivity and resistance to thermal shock. Very brittle. Extreme care must be taken to prevent physical shock.

Resistance Temperature Detectors

RTDs are thermal sensors that change resistance with temperature. The amount of change is dependent on the change in temperature and the specific alloy of the conductor. In certain applications, an RTD is a better choice than a thermocouple.

RTDs are more accurate than thermocouples – especially over a narrow temperature range. Standard accuracy ratings of 0.25% and 0.10% are offered.

The RTD sensing element is a coil of wire – precision wound to a specific resistance value. The element is hermetically sealed in glass to prevent influence from moisture. This element is then mounted in the tip of a metal protection tube for physical protection. Physical configuration of the complete assembly is similar to a thermocouple.

RTDs have been manufactured from several alloys, including copper, nickel and platinum based material. We supply platinum based units in two different coefficients.

The primary advantage of using an RTD is greater accuracy. Disadvantages include higher cost and less resistance to physical shock. Since the element has greater mass, the RTD will respond slower than a thermocouple. The decision to us an RTD versus a thermocouple has to be based on these factors.

Resistance Coefficient

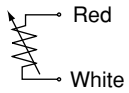
The change in resistance per degree (resistance coefficient) depends on the specific alloy content of the wire. In past years, several coefficients were marketed. Most U.S. manufactured RTDs had coefficients near 0.00391 / /°C. Industry has now standardized on the DIN (Deutsche Industrie-Norm) specification of 0.00385 / /°C. We can supply either sensor.

Overview

RTD Configurations

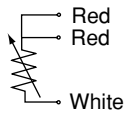
If a sensor relates resistance to temperature, then the resistance of the lead wire can affect the accuracy of the reading. Various methods have been developed to compensate. This has resulted in RTDs being manufactured in two wire, three wire and four wire configurations.

Two Wire



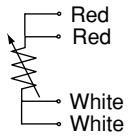
The two wire element has no provision for lead wire compensation other than increasing the size of the lead wire. It is suitable for installations where the distance to the measuring instrument is short, or accuracy is not critical.

Three Wire



The three wire configuration is the industry standard. Two red wires are tied together at the element. The white wire is terminated at the other end of the element. The measuring instrument can sense the resistance of the two red wires, and subtract this from the resistance between one red wire and the white wire. This is accurate as long as all three leads are the same length and gauge.

Four Wire



Four wire RTDs have two wires terminated at each end of the element. Current to the **s**ensor is supplied on one wire, and the voltage value is measured on the other. Since there is no current flowing in the measuring wires, no error is contributed by lead wire resistance. Four wire sensors are usually restricted to laboratory environments.

RTD General Specifications

Element

Platinum wire, 100 at 32°F (0°C). Temperature coefficient of resistance for the range of 0 to 100°C (32 to 212°F) is 0.00385 / /°C, PT 100 (0.00391 / /°C also available).

Repeatability

±0.18°F or better over full range

Stability

Drift is less than ±0.18°F at 32°F after one year normal service within rated temperatures

Time Constant

Five seconds in water at three feet per second

Self Heating

28 mW/°F in water at three feet per second

Vibration

Assembly construction withstands 50 Hz to 2000 Hz at 20 G's minimum MIL STD 202C, method 204A, test condition D

Shock

Element construction withstands minimum 100 G's sine wave shock of eight milliseconds duration, three blows applied to each axis

Intermediate Temperature

Range: -148 to 500°F (-100 to 260°C)
Insulation Resistance: 100 M minimum at 50 Vdc.
Leads: AWG #22, strand nickel plated copper wire. Teflon insulated

High Temperature

Range: -148 to 932°F (-100 to 500°C)
Insulation Resistance: 10 M minimum at 50 Vdc.
Leads: AWG #22, strand nickel plated copper wire. Fiberglass insulated

Protection Tube Materials

304 stainless steel. Good oxidation and corrosion resistance in a wide range of industrial environments. Subject to carbide precipitation which can reduce corrosion resistance in the 800 to 1000°F range. Good mechanical properties from -300 to 1450°F. Regarded as the standard protection tube material.

316 stainless steel. Same areas of application as 304 stainless steel. Improved resistance to mild acid and pitting corrosion.

Specifications (continued)

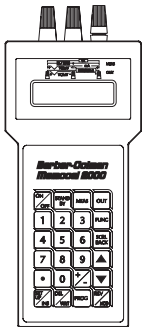
Accuracy

Accuracy tolerances for RTD with ±0.10 or ±0.25% rating.

Rating	Tolerance	Temperature °F										
		0	100	200	300	400	500	600	700	800	900	1000
0.25%	± °F	1.02	1.07	1.33	1.80	2.44	3.05	3.74	4.26	5.08	5.62	6.21
	± Ohms	0.21	0.23	0.28	0.38	0.50	0.61	0.73	0.83	0.94	1.04	1.15
0.10%	± °F	0.32	0.37	0.57	0.81	1.12	1.40	1.75	2.00	2.43	2.60	3.20
	± Ohms	0.07	0.08	0.12	0.17	0.23	0.28	0.35	0.39	0.45	0.49	0.57

Hand Held Calibrator

MEMOCAL 2000



The MEMOCAL 2000 is a lightweight, versatile, hand-held calibrator for use both in the field and laboratory. The small size, simple programming, friendly interface, high noise immunity and long battery life make the MEMOCAL ideal for field maintenance calibration (Reference Accuracy to 0.015%). The optional leather carrying case features an over the shoulder strap and allows for viewing of both the display and the keypad. The high accuracy, large range of I/O capabilities and digital interface make the MEMOCAL ideal for laboratory use. A standard 120/240 Vac adapter saves battery capacity when working at the bench.

The MEMOCAL 2000 simulates and measures 15 different thermocouple, 2 RTD, mA, mV, voltage and ohm signals. A built-in 24 Vdc power supply allows excitation and measurement of 2-wire and 4-wire transmitters. Standard features also include configurable internal or external cold junction compensation, square root extraction and quadratic signal generation.

Up to 50 program steps can be created in one or more programs, providing pre-configured ramp, soak and step functions for calibration zero, span and midpoints. Two dry contact inputs allow program advance and hold.

National Institute of Standards and Technology (NIST) Traceable Certification of New Thermocouple Assemblies, New Thermocouple Wire, and Platinum RTDs

Introduction

The factory will provide a certification report which shows the degrees deviation from a standard at the temperatures certified in accordance with the provisions discussed below.

Certification

A reference RTD or type S thermocouple standard is used for temperatures above 200°F. A liquid-in-glass thermometer or reference RTD is used for temperatures below 200°F.

NIST traceability is available through 2650°F, where appropriate, based on thermocouple type. The minimum length of thermocouple wire or RTD that the factory will certify is 12 inches.

Only new, unused wire, thermocouples, and RTDs are certified.

Certain finished assemblies cannot be certified. The factory will determine if certification for an assembly is appropriate in our facilities.

Aerospace Material Specification AMS-2570, Rev. C, Section 3.1 provides for the use of thermocouples made from calibrated wire rolls. The charge for this service is the same as for certification of two individual thermocouples. All thermocouples on the order must use the same wire and be calibrated to identical temperatures. Consult the factory to determine the maximum number of thermocouples that may be calibrated from one wire length. Specify "end point certification per AMS-2750" when requesting this service.

The factory will not warrant or guarantee that sensors shall have accuracy better than specified in the following tables.

Table 1.
Tolerances on Initial Values of EMF v Temperature for ANSI listed Thermocouples

Type	Range		Tolerance * Reference Junction 0°C (32°F)	
	°C	°F	Standard	Special
			Greater of:	Greater of:
T	0 to 370	32 to 700	±1°C or ±0.75%	±0.5°C or ±0.4%
J	0 to 760	32 to 1400	±2.2°C or ±0.75%	±1.1°C or ±0.4%
E	0 to 870	32 to 1600	±1.7°C or ±0.5%	±1°C or ±0.4%
K or N	0 to 1260	32 to 2300	±2.2°C or ±0.75%	±1.1°C or ±0.4%
R or S	0 to 1480	32 to 2700	±1.5°C or ±0.25%	±0.6 or ±0.1%
B	870 to 1700	1600 to 3100	±0.5%	±0.25%

*°F tolerance is 1.8 times the °C tolerance at the equivalent °C temperature. Percentage tolerances apply only to temperatures expressed in °C.

Tolerances in this table apply to new assembly homogenous thermocouple wire, normally in the size range of 0.25 to 3 mm in diameter (#30 to #8 AWG) and used at temperatures not to exceed ASTM recommendations.

Certification (continued)

Certain characteristics of thermocouple materials, including the EMF v temperature relationship may change with time in use. Consequently, test results and performance obtained at the time of manufacture may not necessarily apply throughout an extended period of use. Tolerances given in this table apply only to new wire as delivered, and do not allow for changes in characteristics with use. The magnitude of such changes will depend on such factors as wire size, temperature, time of exposure and environment. In addition, due to possible changes in homogeneity, attempting to re-calibrate used thermocouples is likely to yield irrelevant results, and is not recommended. However, it may be appropriate to compare used thermocouples in-situ with new or know good ones to ascertain their suitability for further service under the conditions of the comparison.

Table 2.
Non-ANSI Limits of Error Thermocouples

Type	Range	Limits of Error
W-W, 26% Re	0 to 427°C 32 to 800°F	±4.4°C ±8°F
W, 5% Re-W, 26% Re	427 to 2316°C	±1%
W, 3% Re-W, 25% Rh	800 to 4200°F	±1%
Platinel II (Platinel 5355 – Platinel 7674)	0 to 600°C (32 to 112°F) 600 to 700°C (1112 to 1192°F) 700 to 1300°C (1292 to 2372°F)	±0.10 mv ±0.15 mV ±0.20 mV

Table 3.
Platinum RTD

The following classification table represents values for 3 wire and 4 wire Platinum RTDs. Caution must be exercised with 2 wire RTDs because of possible error caused by connecting wires. Tabulated values are based on elements of 100.0 ohms (nominal) at 0°C.

Temp., (1) t (°C) (3)	ASTM Grade A (2) ±0.13 + (0.0017), (t) °C		ASTM Grade B (2) ±0.25 + (0.0042), (t) °C	
	(°C)	Ohm	(°C)	Ohm
-200	0.47	0.20	1.1	0.47
-100	0.30	0.12	0.67	0.27
0	0.13	0.05	0.25	0.10
100	0.30	0.11	0.67	0.25
200	0.47	0.17	1.1	0.40
300	0.64	0.23	1.5	0.53
400	0.81	0.28	1.9	0.66
500	0.98	0.33	2.4	0.78
600	1.15	0.37	2.8	0.88
650	1.24	0.40	3.0	0.94

(1) To convert temperature °C to °F, multiply by 1.8 and add 32. (2) To convert tolerance °C to °F, multiply by 1.8. (3) t = modulus of temperature in degrees Celsius without regard to sign.

Table 4.
Suggested Upper Limits for Sheathed Thermocouples

These suggestions do not take into account environment temperature limitations of the sheath material, nor do they address compatibility considerations between the element materials and the sheath containing them. The actual maximum practical temperature in a particular situation will generally be limited to the lowest temperature among the several factors involved. Consult ASTM MNL 12 “Manual on the Use of Thermocouples in Temperature Measurement” (available from ASTM headquarters) and other literature sources for further application information.

The temperature limits suggested here are intended only as a guide and should not be taken as absolute values, or as guarantees of satisfactory performance. These types and sizes are sometimes used at temperatures above the given limits, but usually at the expense of stability or life, or both. In other instances, it may be necessary to reduce the given limits in order to achieve adequate service.

Certification (continued)

Table 4 (continued)
Suggested Upper Limits for Sheathed Thermocouples

Barber-Colman Part Number		Calibration Type	Sheath		Maximum Suggested Temperature
Special Limits	Standard Limits		Material	Outside Diameter	
MJ12	M112	J	304 SS	0.040"	500°F
MJ22	M122		Inconel 600		
MJ13	M113		304 SS	0.063"	825°F
MJ23	M123		Inconel 600		
MJ33	M133		316 SS		
MJ43	M143		310 SS		
MJ14	M114		304 SS	0.125"	970°F
MJ24	M124		Inconel 600		
MJ34	M134		316 SS		
MJ44	M144		310 SS		
MJ15	M115		304 SS	0.188"	1150°F
MJ25	M125		Inconel 600		
MJ35	M135		316 SS		
MJ45	M145		310 SS		
MJ16	M116		304 SS	0.250"	1330°F
MJ26	M126		Inconel 600		
MJ36	M136		316 SS		
MJ46	M146		310 SS		
MK12	M212	K	304 SS	0.040"	1290°F
MK22	M222		Inconel 600		
MK32	M232		316 SS		
MK42	M242		310 SS		
MK13	M213		304 SS	0.063"	1600°F
MK23	M223		Inconel 600		1690°F
MK33	M233		316 SS		
MK43	M243		310 SS		
MK14	M214		304 SS	0.125"	1600°F
MK24	M224		Inconel 600		1960°F
MK34	M234		316 SS		1700°F
MK44	M244		310 SS		1960°F
MK64			MI 2300	0.188"	2300°F
MK15	M215		304 SS		1600°F
MK25	M225		Inconel 600		2100°F
MK35	M235		316 SS		1700°F
MK45	M245		310 SS		2100°F
MK16	M216		304 SS	0.250"	1600°F
MK26	M226		Inconel 600		2100°F
MK36	M236		316 SS		1700°F
MK46	M246		310 SS		2100°F
MK66			MI 2300		2300°F
ME12	M312	E	304 SS	0.040"	570°F
ME13	M313			0.063"	950°F
ME14	M314			0.125"	1200°F
ME15	M315			0.188"	1350°F
ME16	M316			0.250"	1510°F
ME34	M334			0.125"	1200°F
MT12	M412	T	304 SS	0.040"	500°F
MT13	M413			0.063"	
MT14	M414			0.125"	600°F
MT15	M415			0.188"	700°F
MT16	M416			0.250"	
MJ43-90000	M143-90000	J	310 SS	0.063"	825°F
MJ14-90000	M114-90000		304 SS	0.125"	970°F
MJ15-90000	M115-90000			0.188"	1150°F
MJ16-90000	M116-90000		310 SS	0.250"	1330°F
MK23-90000	M223-90000	K	Inconel	0.063"	1690°F
MK24-90000	M224-90000			0.125"	1960°F
MK25-90000	M225-90000			0.188"	2100°F
MK26-90000	M226-90000			0.250"	
ME14-90000	M314-90000	E	304 SS	0.125"	1200°F
MT16-90000	M416-90000	T		0.250"	700°F

Certification (continued)

Table 5
Recommended T/C and RTD Certification Temperature Ranges

The following table shows the allowable temperature limits for commonly used thermocouples and RTDs. These limits apply to thermocouples in conventional closed end protection tubes. In any general recommendations of temperature elements, it is not practicable to take into account special cases. In actual operation there may be instances where the temperature limits recommended can be exceeded. Likewise, there may be applications where satisfactory life will not be obtained at the recommended temperature limits. However, in general, the temperature limits listed are such as to provide satisfactory element life when the wires are operated continuously at these temperatures.

Type	Gauge	°F Range	°C Range
J	8	-70 to 1400	-57 to 760
	14	-70 to 1100	-57 to 593
	20	-70 to 900	-57 to 482
	24	-70 to 700	-57 to 371
K or N	8	-70 to 2300	-57 to 1260
	14	-70 to 2000	-57 to 1093
	20	-70 to 1800	-57 to 982
	24	-70 to 1600	-57 to 870
T	14	-70 to 700	-57 to 371
	20	-70 to 500	-57 to 260
	24	-70 to 400	-57 to 200
E	8	-70 to 1600	-57 to 871
	14	-70 to 1200	-57 to 649
	20	-70 to 1000	-57 to 538
R or S	24	-50 to 2650	-46 to 1454
B	24	32 to 2650	0 to 1454
0.00385 Platinum RTD		-70 to 450	-57 to 232
0.00391 Platinum RTD		-70 to 450	-57 to 232

Ordering Information

Certification at temperatures of 200° to 2650°F (93 to 1454°C)
For thermocouple, thermocouple wire, or RTD consult price list

Certification at temperatures of 32° to 199°F (0 to 93°C)
For thermocouple, thermocouple wire, or RTD consult price list
Dual element sensors are priced as two individual sensors.

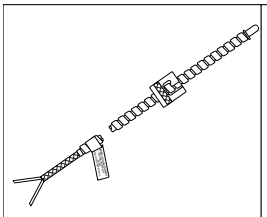
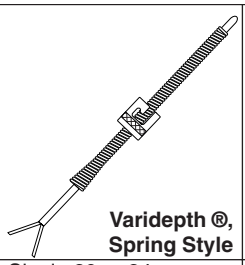
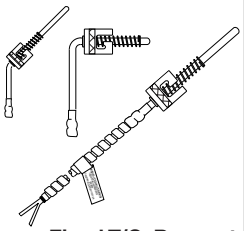
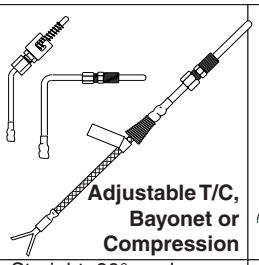
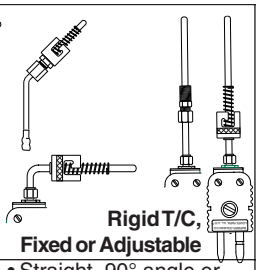
Certification is not available for ring, bolt or lug type thermocouples. Sensors are calibrated to ITS-90 except where reference tables are referenced to IPTS-68.

Consult factory for cost of certification at temperatures below 0°C, or above 1454°C.

Thermocouple Selector

- **Types J, K, E, or T**
- **20 or 24 gauge**
- **Stripped, lugs, or plug/jack connector**
- **Single or dual element (if compatible)**

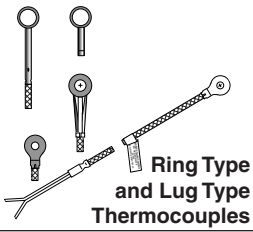
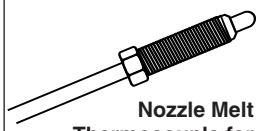
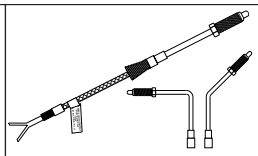
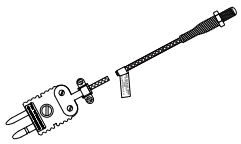
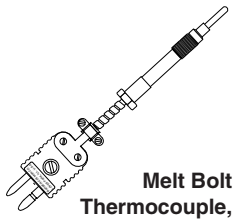
Thermocouples for Plastic Molding and Extrusion

	Varidepth ®, Armor Clad	Varidepth ®, Spring Style	Fixed T/C, Bayonet	Adjustable T/C, Bayonet or Compression	Rigid T/C, Fixed or Adjustable
					
Options	• Single 20 or 24 gauge element; dual 24 gauge • Cap for 12 mm adapter • Cap for 15 mm adapter	• Single 20 or 24 gauge element; dual 24 gauge • Brass tip • Stainless steel overbraid on flexible length • Cap for 12 mm adapter • Cap for 15 mm adapter	• Straight, 90° angle or 45° angle probe • Fiberglass insulation with or without SS overbraid and/or armor clad tube on flexible length	• Straight, 90° angle or 45° angle probe • Fiberglass insulation with or without SS overbraid and/or armor clad tube on flexible length • Adjustable bayonet lock cap or threaded compression fitting mount	• Straight, 90° angle or 45° angle probe • Adjustable bayonet lock cap or threaded compression fitting mount • Miniature plastic weatherproof head also available for cold end connection
Applications	These are general purpose thermocouples whose primary usage is on the barrels, nozzles and molds of plastic injection and plastic extrusion machinery. They are available in a wide variety of lengths, configurations and calibrations to meet virtually any need in the plastics manufacturing industries. Resistance temperature detectors are also available.				
Features	•Locking cap adjusts to any position • Holds probe tip firmly against well bottom • T/C at tip for maximum heat transfer • Types J, K, E up to 750°F over probe and tube • Type T up to 500°F	•Locking cap adjusts to any position • Holds probe tip firmly against well bottom • T/C at tip for maximum heat transfer • Maximum 750°F over probe and tube	•Locking cap holds probe tip firmly against well bottom • T/C at tip for maximum heat transfer • Maximum 900°F over probe and tube	• T/C at tip for maximum heat transfer • Maximum 900°F over probe and tube	• T/C at tip for maximum heat transfer • Maximum 900°F over probe and tube except Type T is 700°F
Comments	Adjust to various depths thus eliminating the need to stock several fixed immersion depth sensors.	Adjust to various depths thus eliminating the need to stock several fixed immersion depth sensors.	Immersion depth fixed at factory as specified on order.	Bayonet lock available on 1/8" diameter tube only. Immersion depth fixed when sensor installed.	Adjustable bayonet lock available on 1/8" diameter tube only. Immersion depth of fixed depth models set at factory; adjustable depth set when sensor installed.
Popular Models	P011-33000-YYY-6-00 P011-33100-YYY-6-00 P011-33300-YYY-6-00	P111-31000-YYY-B-00 P111-31100-YYY-B-00 P111-31300-YYY-B-00	P011-33000-YYY-4-ZZ P011-33100-YYY-4-ZZ P011-33300-YYY-4-ZZ P111-31000-YYY-4-ZZ P111-31100-YYY-4-ZZ P111-31300-YYY-4-ZZ	P011-330XX-YYY-2-00 P011-331XX-YYY-2-00 P011-333XX-YYY-2-00 P111-310XX-YYY-2-00 P111-311XX-YYY-2-00 P111-313XX-YYY-2-00	P021-213XX-000-4-04 P021-343XX-000-2-00 P011-313XX-000-4-02
Page	2-10	2-14	2-18	2-24	2-26

Thermocouple Selector

- **Types J, K, E, or T**
- **20 or 24 gauge**
- **Stripped, lugs, or plug/jack connector**
- **Single or dual element (if compatible)**

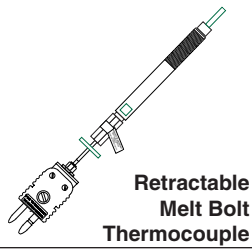
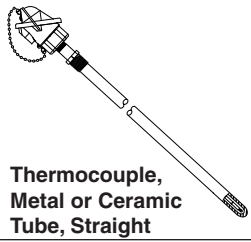
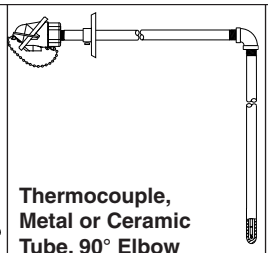
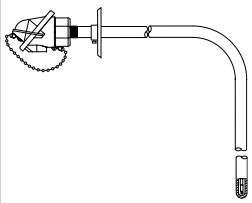
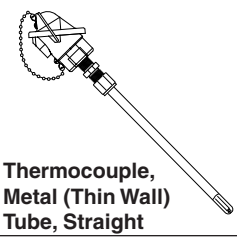
Thermocouples for Plastic Molding and Extrusion

	 **Ring Type and Lug Type Thermocouples**	 **Nozzle Melt Thermocouple for Injection Molding (MgO Insulated)**	 **Nozzle Melt Thermocouple for Injection Molding (Fiberglass Insulated)**	 **Non-Immersion Nozzle Thermocouple**	 **Melt Bolt Thermocouple, Fixed Depth Immersion**
Options	• Fiberglass insulated flexible lead with or without stainless steel overbraid	• Fiberglass insulated flexible lead with or without armor clad tube	• Straight, 90° angle or 45° angle probe • Fiberglass insulated flexible lead with or without stainless steel overbraid	• Fiberglass insulation of flexible lead with or without stainless steel overbraid	• MgO insulated • Fiberglass insulated with armor clad flexible lead • 3", 4", and 6" bolt lengths standard; other lengths available
Applications	Surface temperature sensing – such as barrel or mold. Often connected in parallel with another T/C to control average temperature.	Each of these sensors is designed with a melt bolt mounting system that provides highly sensitve and accurate reading of the temperature of the plastic melt in an injection molding machine. Choose from MgO insulated and Fiberglass insulated sensors with specified immersion depth; or select the non-immersion nozzle thermocouple.			Specially designed for melt stream of extruder. Provides accurate reading for tight control, smooth, consistent flow.
Features	• Available in copper or stainless steel • Rings and lugs to fit many stud sizes	• Temperature rating of 750° excluding cold end termination • Probe can be formed over mandrel to any desired angle at installation.	• Temperature rating of 750° excluding cold end termination	• 1/4-28 thread size • Fast response	• 1/2-20 UNF-2A mounting thread • Fast response
Comments	Typical process mount (bayonet lock, or compression fitting) not applicable. Ring or lug T/C tip is placed over threaded stud and secured with a nut.	T/C tip held firmly against chamfer seat by hole bolt on probe Fixed immersion depth Type J only	T/C tip held firmly against chamfer seat by hole bolt on probe Fixed immersion depth Type J only	Type J only	Type J only
Popular Models	P071-00100-024-7-02 P081-00200-036-7-11 P131-00300-018-7-10	P161-41F03-012-5-01 P161-41300-012-5-01	P151-21105-018-5-01	P131-21100-036-8-00 P261-21000-024-8-00	P011-51103-012-1-01 P161-41304-006-1-03 P161-51306-000-1-00
Page	2-30	2-32	2-32	2-34	2-36

Thermocouple Selector

- **Base Metal Alloys**
- **Types J, K, E, T, N**
- **Standard or Special Limits Wire**
- **Single or Dual Elements**

Base Metal Thermocouples for Industrial Applications

	 **Retractable Melt Bolt Thermocouple**	 **Thermocouple, Metal or Ceramic Tube, Straight**	 **Thermocouple, Metal or Ceramic Tube, 90° Elbow**	 **Thermocouple, Metal Pipe, 90° Bend**	 **Thermocouple, Metal (Thin Wall) Tube, Straight**
Options	• Single or Dual element • 3", 5" or 7" bolt • Support tube surrounding probe	• Metal or ceramic tube • Open or closed end • Grounded or ungrounded junction • Twisted or butt welded junction • Large selection of protection tube materials and cold end termination	• Metal or ceramic hot leg • Open or closed end • Grounded or ungrounded junction • Twisted or butt welded junction • Large selection of protection tube materials and cold end termination	• Open or closed end • Grounded or ungrounded junction • Twisted or butt welded junction • Large selection of protection tube materials and cold end termination	• Open or closed end • Grounded or ungrounded junction • Twisted or butt welded junction • Stainless steel or Inconel protection tube • Large selection of cold end termination
Applications	Measures temperature of melt stream of extruders to provide accurate control and facilitate consistency and smooth flow.	General purpose, but especially appropriate for severe and demanding environments.	Salt baths, heat treating and molten metal applications.	Particularly appropriate for molten metal applications	General purpose use.
Features	• Adjustable from 1/8" to 1" depth immersion standard; other ranges available • Fast response; rated to 900°F	• Heavy wall to provide long life of thermocouple in harsh atmosphere • Variety of pipe materials to use in different atmospheres	• Easy to use in molten pots or hanging applications	• Same material entire length of protection tube for optimum thermocouple protection	• Fast response • Variety of tube materials to use in different atmospheres
Comments	Type J only; MgO insulated	Threaded bushing or flange mount. Vertical mounting recommended to prevent sagging.	Mounting flange optional.	Mounting flange optional.	Compression fitting process mount, or double ended bushing mount available.
Popular Models	A-10528-100-0-XX A-10528-100-1-XX	J08I-19112-000-0-00 J08I-19112-000-8-10 K08I-16112-000-0-00 K08I-16112-000-8-10 K08I-17124-000-8-22	K08L-01112-012-0-00 K08L-12118-012-0-00 K08L-41118-012-0-00 J08L-41118-012-0-00 J08L-12118-012-0-00	J08A-12118-012-0-00 K08A-12118-012-0-00 K08A-16118-012-0-00	J14I-66318-000-7-00 J20H-67324-000-0-00 K20I-69524-000-7-00
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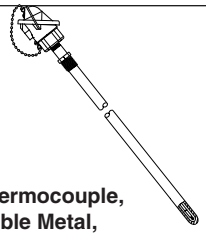
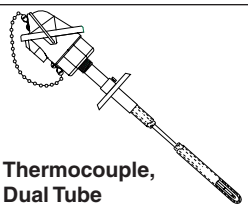
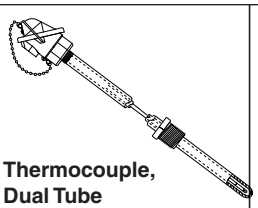
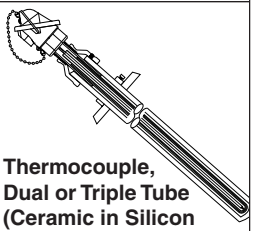
Thermocouple Selector

Noble Metal Thermocouples for Industrial Applications

- **Noble Metal Alloys**
- **Types B, R, S, C, F**
- **Standard or Special Limits Wire**
- **Single or Dual Elements**

	 **Thermocouple, Noble Metal, Ceramic Tube, Straight**	 **Thermocouple, Dual Tube (Ceramic in Ceramic) Straight**	 **Thermocouple, Dual Tube (Ceramic in Inconel) Straight**	 **Thermocouple, Dual or Triple Tube (Ceramic in Silicon Carbide) Straight**
Options	• Open or closed end • Grounded or un-grounded junction • Twisted or butt welded junction • Mullite or aluminum oxide tube • Large selection of cold end termination	• Mullite or aluminum oxide tubes • Large selection of cold end termination	• Mullite or aluminum oxide primary tube • Large selection of cold end termination	• Mullite or aluminum oxide primary tube • Mullite or aluminum oxide middle tube • Large selection of cold end termination
Applications	• Heat treating, forging, or annealing • Ceramics and glass industry • Semi-conductor manufacturing • Research laboratories	• Heat treating, forging, or annealing • Ceramics and glass industry • Semi-conductor manufacturing • Research laboratories	• Furnace, kilns, or where protection tube is subject to thermal or mechanical shock • Heat treating, carburizing, nitriding, salt baths, blast furnace operation, and gas generators	• Molten non-ferrous metals • Brick kilns • Ceramic kilns • Incinerators • Wherever sensor is exposed to flames or hot gasses
Features	• Aluminum oxide tube impervious to gasses up to 3200°F	• Aluminum oxide tube impervious to gasses up to 3200°F	• Inconel 601 protection tube high resistance to thermal and mechanical shock; resists oxidation up to 2300°F and corrosion at high temperature	• Silicon carbide protection tube has low lag time and long life.
Comments	• Threaded bushing or flange mount available • Vertical mounting recommended • Inert gas tube seal optional	• Threaded bushing or flange mount available • Vertical mounting recommended • Inert gas tube seal optional	• Threaded bushing or flange mount available • Inert gas tube seal optional • Inconel 601 tube subject to embrittlement in hydrogen	• Adjustable flange process mount optional • Inert gas tube seal optional
Popular Models	R24I-29318-000-7-00 S24I-30A12-000-3-00 C24I-30224-010-3-00	R24I-29118-100-3-00 S24H-30224-100-5-00	R24I-29318-600-F-12 S24H-30224-600-0-00	S24I-30318-200-0-00 R26I-29A24-300-0-00
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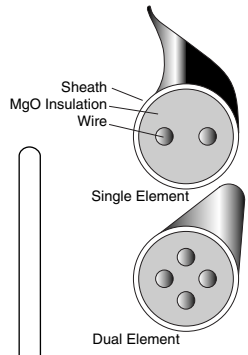
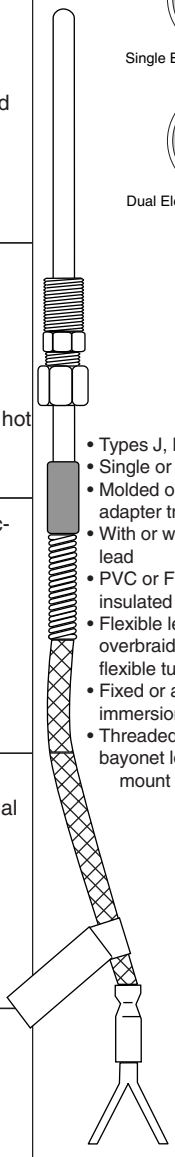
Looking for MgO Insulated T/Cs?

See Section 4 of this book!





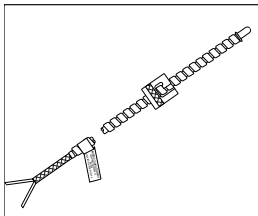
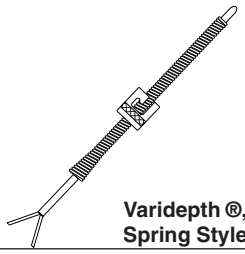
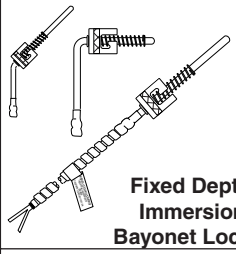
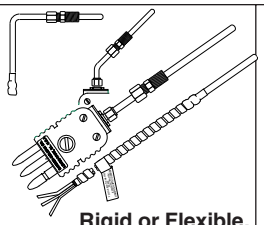
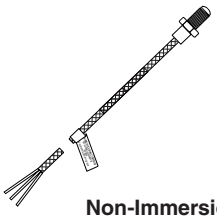
- Types J, K, E, T, S, N
- Single or dual element
- Molded or metal potting adapter transition
- With or without flexible lead
- PVC or Fiberglass insulated flexible lead
- Flexible lead with SS overbraid or armor clad flexible tube
- Fixed or adjustable immersion depth
- Threaded bushing or bayonet lock process mount

BARCOPAC™ by Barber-Colman

RTD Selector

- 0.00391 / /°C or 0.00385 / /°C
- 0.10% or 0.25% accuracy
- 2 or 3 wire
- Stripped, lugs, or plug/jack connector
- Single or dual element (if compatible)

Resistance Temperature Detectors for Plastic Molding and Extrusion

	Varidepth ®, Armor Clad	Varidepth ®, Spring Style	Fixed Depth Immersion, Bayonet Lock	Rigid or Flexible, Fixed or Adjustable	Non-Immersion Nozzle RTD
					
Options	• Cap for 12 mm adapter • Cap for 15 mm adapter	• 6 or 12 inch spring • Cap for 12 mm adapter • Cap for 15 mm adapter	• RTD with Type J thermocouple • Straight, 90° angle or 45° angle probe • Fiberglass insulation with or without SS overbraid and/or armor clad tube on flexible length	• RTD with Type J thermocouple • Straight, 90° angle or 45° angle probe • Fiberglass insulation with or without SS overbraid and/or armor clad tube on flexible length	• Single element only
Applications	These are general purpose RTDs whose primary usage is on the barrels, nozzles and molds of plastic injection and plastic extrusion machinery. They are available in a wide variety of lengths, configurations and calibrations to meet virtually any need in the plastics manufacturing industries. Thermocouples are also available.				
Features	•Locking cap adjusts to any position • Holds probe tip firmly against well bottom • RTD at tip for maximum heat transfer	•Locking cap adjusts to any position • Holds probe tip firmly against well bottom • RTD at tip for maximum heat transfer	•Locking cap holds probe tip firmly against well bottom • Sensor(s) at tip for maximum heat transfer	•Compression fitting used for fast mounting • RTD at tip for maximum heat transfer	• RTD at tip for maximum heat transfer • Fast response • 1/4-20 NF mounting thread
Comments	Adjust to various depths thus eliminating the need to stock several fixed immersion depth sensors.	Adjust to various depths thus eliminating the need to stock several fixed immersion depth sensors.	Immersion depth fixed at factory as specified on order.	Immersion depth fixed at factory as specified on order; or, of adjustable models, set when sensor installed	Temperature range: -148° to 932°F (-100 to 500°C), except 350°F (176°C) when equipped with plug connector.
Popular Models	P711-33100-018-6-00 P731-33300-024-6-00 P711-33100-036-6-00	P711-31000-024-A-00 P711-31100-018-B-00 P741-31100-036-A-00	P711-31000-000-4-06 P761-33300-000-4-03 P721-31200-000-4-04	P711-31306-024-2-00 P721-33006-018-2-00 P741-31108-012-3-00	P721-00200-048-5-00 P751-00300-024-5-00
Page	2-13	2-16	2-22	2-28	2-35

RTD Selector

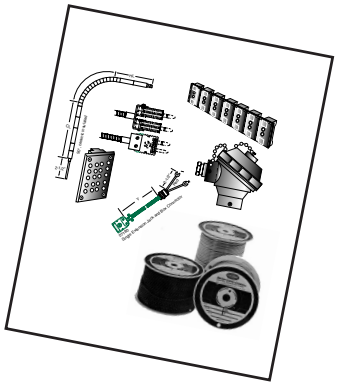
RTD for Plastics

Thermistor

Resistance Temperature Detector for Industrial Applications

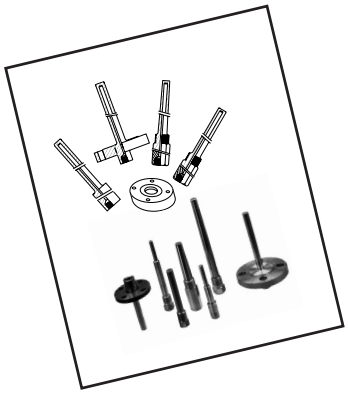
	Melt Bolt RTD	Fixed or Adjustable Immersion Depth	Fixed or Adjustable Immersion Depth
Options	• Single element only • 3” Bolt length • 4” Bolt length • 6” Bolt length • Other bolt lengths available	• 10 k , 100 k or 1 M at 25°C • With or without J T/C • Straight, 90° angle or 45° angle probe • Stripped, lugs, or plug/jack cold end connector • With or without armor clad flexible length	• 0.00391 / /°C or 0.00385 / /°C • 0.10% or 0.25% accuracy • 3 or 4 wire • Flexible lead • Teflon or Fiberglass insulation with or without armor clad or stainless steel overbraid
Applications	Specially designed for melt stream of extruder. Provides accurate reading for tight control, smooth consistent flow.	This is a specialized sensor with limited, but general use. Typically considered a replacement item.	High accuracy sensor for use in industrial and laboratory applications.
Features	• 0.00391 / /°C • 0.00385 / /°C • 1/2-20 UNF-2A Threads	• Rapid response • Easy to detect minor temperature changes	• Very linear • Very stable
Comments	Temperature range: -148° to 932°F (-100 to 500°C), except 350°F (176°C) when equipped with plug connector.	Fixed depth set at factory per purchase order; adjustable depth set at time of installation.	Single or dual element (if compatible); Stripped, lugs, plug/jack, or large selection of cold end heads.
Popular Models	P731-52304-012-1-05 P721-42303-006-1-00	P721-33104-018-2-00 P431-33005-024-4-03 P211-33104-018-2-00	R711-66112-036-4-03 R711-65318-024-8-10
Page	2-38	2-20	3-22

Need thermocouple wire? extension wire? plugs? jacks? insulators? replacement elements? protection tubes? bushings?



See the Wire and Accessories section of this book!

Thermowells? Thermowell assemblies? We got ‘em!

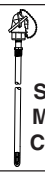
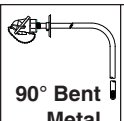
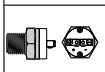


See the Thermowells section of this book!

Options, Plastics Sensors

		Varidepth ® Sensors		Probe Sensors						Specific Use Sensors					
		(See pages 2-14 and 2-18 for RTDs)		45° Straight 90°						Ring, Lug	Nozzle Melt			Melt Bolt (See page 2-41 for Retractable T/C)	
		Flexible Armor	Spring Style	Immersion Depth-Fixed or Adjustable							T/C	Non-Immersion			
				T/C			RTD					T/C	RTD	T/C	RTD
				F	A	F or A	F	F or A	F or A						
	Details on page:	2-10	2-14	2-18	2-24	2-26	2-22	2-20	2-28	2-30	2-32	2-34	2-35	2-36	2-38
Element	Type	J, K, E, T	J, K, E, T	J, K, E, T			N/A	N/A	N/A	J, K	J	J	N/A	J	N/A
Element	Single	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	N/A	Yes	N/A	N/A	Yes	Yes
Element	Dual	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	NA	No	N/A	N/A	Yes	Yes
Junction Style	Closed, Grounded	Yes	Yes	Yes	Yes	Yes	N/A			N/A	Yes	N/A	N/A	Yes	N/A
Junction Style	Closed, Ungrounded	Yes	Yes	Yes	No	Yes				N/A	Yes	N/A	N/A	Yes	N/A
Junction Style	Open, Grounded	No	No	Yes	Yes	Yes				N/A	No	N/A	N/A	No	N/A
Process Mounts	Bayonet, Fixed Depth	Not applicable. Varidepth uses bayonet style mount inherent in the design of the sensor that allows the sensor to be immersed to various depths.		Yes	No	Yes	Yes	Yes	No	Sensor Tip Mount	Melt Bolt Mount	Sensor Tip Mount		Melt Bolt Mount	
Process Mounts	Bayonet, Adjustable Depth			No	Yes	No	No	No	No						
Process Mounts	Compression Fitting, Adjustable Depth			No	Yes	Yes	No	No	Yes						
Process Mounts	Brazed Bushing, Fixed Depth			No	No	No	No	No	Yes						
Flexible Lead Protection	Stainless Steel Overbraid	No	Yes	Yes	Yes	N/A - Rigid probe mounted directly to head	Yes	Yes	Yes	N/A	Yes	Yes	No	Yes	N/A
Flexible Lead Protection	Flexible Armor	Inherent in sensor design	No	Yes	Yes		Yes	Yes	Yes	N/A	Yes	No	No	Yes	N/A
Flexible Lead Protection	None – Fiberglass Insulation	Extended lead only	Inherent in sensor design	Yes	Yes		No	No	No	N/A	Yes	Yes	No	No	N/A
Cold End Termination	Weatherproof Head	No	No	No	No	Yes	No	No	No	No	No	No	No	No	N/A
Cold End Termination	Stripped	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	N/A
Cold End Termination	Spade Lugs	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	N/A
Cold End Termination	Spade Lugs with Box Connector	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	N/A
Cold End Termination	Quick Disconnect Plug	Type J only	Type J only	Type J only	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	N/A
Cold End Termination	Quick Disconnect Plug with Mating Jack	Type J only	Type J only	Type J only	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	N/A
Cold End Termination	Quick Disconnect Jack	No	No	No	Yes	Yes	No	No	No	No	No	No	No	No	N/A

Options, Industrial Sensors

		Base Metal				Noble Metal			
		 Straight Metal or Ceramic	 90° Elbow Metal or Ceramic	 90° Bent Metal Tube	 Thin Wall	 Straight Ceramic	 Dual Ceramic in Ceramic	 Dual Ceramic in Inconel	 Dual or Triple Ceramic in Silicon Carbide
	Details on page:	3-4	3-7	3-10	3-12	3-14	3-16	3-18	3-20
Wire	Type	J, K, E, T, N				B, R, S, C, F			
Wire	Gauge	8, 4, 20			14, 20	24, 25, 26			
Primary Protection Tube	Steel	Yes		Yes	No	No			
Primary Protection Tube	Stainless Steel			Yes	Yes				
Primary Protection Tube	Nickel			No	Yes				
Primary Protection Tube	Inconel			Yes	No				
Primary Protection Tube	Incoloy			Yes	No				
Primary Protection Tube	Cast Iron			No	No				
Primary Protection Tube	Mullite			No	No	Yes			
Primary Protection Tube	Aluminum Oxide			No	No				
Primary Protection Tube	Silicon Carbide			No	No	No			
Process Mounts	 Adjustable Flange	Yes	Yes	Yes	No	No	No	Yes	Yes
Process Mounts	 Sleeve	Yes	No	No	No	Yes	Yes	No	No
Process Mounts	 Double Ended Bushing	Yes	No	No	Yes	Yes	Yes	No	No
Process Mounts	 Welded Bushing	Yes	No	No	No	No	No	Yes	No
Process Mounts	 Compression Fitting	No	No	No	No	Yes	No	No	No
Heads	 General Purpose, Cast Iron, Aluminum	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Heads	 Weatherproof, Cast Iron, Aluminum	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Heads	 Aluminum, Transmitter Ready	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Heads	 Weatherproof, Plastic	No	No	No	Yes	Yes	No	No	No
Heads	 Explosionproof, Class I, II; Groups A, B, C, D, E, F, G	Yes	Yes	Yes	Yes	No	No	Yes	No
Heads	 Explosionproof, Cast Iron Body, Aluminum Cover	Yes	Yes	Yes	Yes	No	No	No	No
Heads	 Miniature	No	No	No	Yes	No	No	No	No
Heads	 Ceramic Wafer	No	No	No	Yes	No	No	No	No
Heads	 Open Terminal	No	No	No	No	Yes	Yes	Yes	Yes
	 Quick Disconnect Plug	No	No	No	No	Yes	No	No	No

Ask about our Temperature and Process Controllers: