

Thermocouples

Quality Control

All Watlow Gordon thermocouple products are manufactured under rigid quality controls. Watlow Gordon's Quality Assurance system is established in accordance with MIL-Q-9858. In addition, all emf vs. temperature calibration procedures follow one or more of the following standards:

- ASTM E 207 (ANSI Approved)
- ASTM E 220 (ANSI Approved)
- NBS Circular 590

All testing has NBS traceability. Unless otherwise specified, all Serv-Rite® thermocouple wire and extension wire are supplied to meet Standard Tolerances of ANSI Circular MC96.1-1982. Special Tolerances per ANSI MC96.1 are also available at an extra charge.

Initial Calibration Tolerances for Thermocouples

Reference Junction 0°C (32°F)

Thermocouple Type	Temperature Range		Tolerances †	
	°C	°F	Standard (whichever is greater)	Special
B	870 to 1700	1598 to 3092	± 0.5%	
E	0 to 900	32 to 1652	± 1.7°C or ± 0.5%	± 1.1°C or ± 0.4%
J	0 to 750	32 to 1382	± 2.2°C or ± 0.75%	± 1.1°C or ± 0.4%
K	0 to 1250	32 to 2282	± 2.2°C or ± 0.75%	± 1.1°C or ± 0.4%
N	0 to 1250	32 to 2282	± 2.2°C or ± 0.75%	± 1.1°C or ± 0.4%
R or S	0 to 1450	32 to 2642	± 1.5°C or ± 0.25%	± 0.6°C or ± 0.1%
T	0 to 350	32 to 662	± 1.0°C or ± 0.75%	± 0.5°C or ± 0.4%
E*	Cryogenic Ranges		± 1.7°C or ± 1%	**
	-200 to 0	-328 to 32		
K*	-200 to 0	-328 to 32	± 2.2°C or ± 2%	**
T*	-200 to 0	-328 to 32	± 1.0°C or ± 1.5%	**

* Thermocouples and thermocouple material are normally supplied to meet the tolerances specified in the table for the normal specified range. The same materials, however, may not fall within the cryogenic tolerances in the second section of the table. If materials are required to meet the cryogenic tolerances, the purchase order must so state. Selection of materials usually will be required. Tolerances indicated in this table are not necessarily an indication of the accuracy of temperature measurements in use after initial heating of the materials.

** Little information is available to justify establishing special tolerances for cryogenic temperatures. Limited experience suggests the following tolerances for types E and T thermocouples:

Type E -200 to 0°C ± 1.0°C or ± 0.5% (whichever is greater)

Type T -200 to 0°C ± 0.5°C or ± 0.8% (whichever is greater)

These tolerances are given only as guide for discussion between purchaser and supplier. Due to the characteristics of the materials, cryogenic tolerances for Type J thermocouples and special cryogenic tolerances for Type K thermocouples are not listed.

† Where tolerances are given in percent, the percentage applies to the temperature being measured in degrees Celsius. For example, the standard tolerance of Type J over the temperature range 277° to 750°C is ± 0.75 percent. If the temperature being measured is 538°C, the tolerance is ± 0.75 percent or 538, or ± 4.0°C. To determine the tolerance in degrees Fahrenheit, multiply the tolerance in degrees Celsius times 1.8.

ANSI Letter Designations

Thermocouple and extension wires are generally ordered and specified by ANSI letter designations for wire type. Positive and negative legs are identified by the appropriate letter suffixes P and N, respectively.

ANSI Letter	Description	Magnetic	Popular Generic & Trade Names*
T	TP	No	Copper
	TN	No	Constantan, Cupron, Advance
J	JP	Yes	Iron
	JN	No	Constantan, Cupron, Advance
E	EP	No	Chromel, Tophel, HAI KP
	EN	No	Constantan, Cupron, Advance
K	KP	No	Chromel, Tophel, HAI KP
	KN	Yes	Alumel, Nial, HAI KN
R	RP	No	Platinum 13% Rhodium
	RN	No	Pure Platinum
S	SP	No	Platinum 10% Rhodium
	SN	No	Pure Platinum
B	BP	No	Platinum 30% Rhodium
	BN	No	Platinum 6% Rhodium
N	NP	No	Nicrosil
	NN	No	Nisil

* Trade Names: Cupron, Nial and Tophel—AMAX • Advance, HAI KP, and HAI-KN—Harrison Alloy Co. • Chromel and Alumel—Hoskins Mfg. Co.

Thermocouple Selection

Thermocouples must be selected to meet the conditions of the application. Only general recommendations on size and type can be given. Some of the considerations involved are length of service, temperature, atmosphere and desired response time. The temperature ranges of the commonly used thermocouple types are given in the Initial Calibration Tolerances Table. Smaller gauge sizes provide faster response at the expense of service life at the elevated temperatures. Larger gauge sizes provide longer service life at the expense of response time. See ANSI Circular MC96.1. As a general rule, it is advisable to protect thermocouple elements with a suitable protecting tube or drilled well.

When ordering thermocouple wire or elements, be certain that the type (K, J, E, etc.) corresponds to that of the instrument with which it will be used. This information can usually be found on the face of the instrument.

• **Type E:** The Type E thermocouple is suitable for use at temperatures up to 1652°F (900°C) in a vacuum, inert, mildly oxidizing or reducing atmosphere. At cryogenic temperatures, the thermocouple is not subject to corrosion. This thermocouple has the highest EMF output per degree of all the commonly used thermocouples.

- **Type J:** May be used, protected or unprotected, where there is a deficiency of free oxygen, but, again for cleanliness and generally longer life, a protecting tube is recommended. Since JP (Iron) wire will oxidize rapidly at temperatures over 1000°F (538°C), it is recommended that larger gauge wires be used to compensate. Maximum recommended operating temperature is 1400°F (760°C).
- **Type K:** Due to its reliability and accuracy, Type K is used extensively at temperatures up to 2300°F (1260°C). It is good practice always to protect this type of thermocouple with a suitable metal or ceramic protecting tube, especially in reducing atmospheres. In oxidizing atmospheres, such as electric furnaces, tube protection is not always necessary when other conditions are suitable; however, it is recommended for cleanliness and general mechanical protection. Type K will generally outlast Type J because the JP (Iron) wire rapidly oxidizes, especially at the higher temperatures. Standard wire finishes are 14 B & S gauge and larger, oxidized; 16 B & S gauge and smaller, bright annealed.
- **Type N:** Nicrosil/Nisil nickel-based thermocouple alloy used primarily at high temperature (up to 2300°F). While not a direct replacement for Type K, Type N provides better resistance to oxidation at high temperature and longer life in applications where sulfur is present. It also outperforms Type K in K's aging range.
- **Type T:** This thermocouple can be used in either oxidizing or reducing atmospheres but for cleanliness and generally longer life, a protecting tube is recommended. Because of its stability at lower temperatures, this is a superior thermocouple for a wide variety of applications in low and cryogenic temperatures. Operating range -328 to 662°F (-200 to 350°C) but can be used to -452°F (-269°C) (boiling helium).
- **Types S, R and B:** Maximum recommended operating temperature for type S or R is 2642°F (1450°C); type B is recommended for use at as high as 3092°F (1700°C). These thermocouples are easily contaminated. Reducing atmospheres are particularly damaging to the calibration. Noble metal thermocouples should always be protected with gas-tight Serv-Rite ceramic tubes, a secondary tube of porcelain, and silicon carbide or metal outer tubes as conditions require. **Types S and R thermocouples and thermoelements are provided in accordance with IPTS-68, unless IPTS-48 is specifically requested. Type B thermocouples and thermoelements meet both IPTS-48 and IPTS-68. (ITS-90 when released)**
- **Tungsten 5% Rhenium/Tungsten 26% Rhenium:** This refractory metal thermocouple may be used at temperatures up to 4200°F (2315°C). As it has no oxidation resistance its use is restricted to vacuum, hydrogen or inert atmospheres.

Note: Temperatures are in relation to table # 7, page 15, of ANSI MC96.1, August, 1982.

Recommended Upper Temperature Limits For Protected Thermocouples Upper Temperature Limit For Various Wire Sizes (AWG), (°C/°F)

Thermocouple Type	No. 8 Gauge	No. 14 Gauge	No. 20 Gauge	No. 24 Gauge	No. 28 Gauge
B				1700/3115	
E	870/1600	650/1200	540/1005	430/805	430/805
J	760/1400	590/1095	480/895	370/700	370/700
K & N	1260/2300	1090/1995	980/1795	870/1600	870/1600
R & S				1480/2720	
T		370/700	260/500	200/395	200/395

Table courtesy of American National Standards Institute