Thermocouples

ANSI Tolerances

As of 1969, nomenclature of the American National Standards Institute, Inc. (ANSI) supersedes previously used International Society of Automation (ISA) designations. The standard and special tolerances in the table below come from ANSI Circular ASTM E230.

Standard and special tolerances stated below apply only to temperature ranges listed for each thermocouple type.

Letter Designations

ANSI Letter	T/C Leg	Popular Generic and Trade Names
B	BP BN	Platinum 30% Rhodium Platinum 6% Rhodium
E	EP EN	Chromel®, Tophel®, HAI-KP® Constantan, Cupron®, Advance®
J	JP JN	Iron Constantan, Cupron®, Advance®
K	KP KN	Chromel®, Tophel®, HAI-KP® Alumel®, Nail®, HAI-KN®
N	NP NN	Nicrosil Nisil
R	RP RN	Platinum 13% Rhodium Pure Platinum
S	SP SN	Platinum 10% Rhodium Pure Platinum
T	TP TN	Copper Constantan, Cupron, Advance

Sheath Tolerances

Length and diameter are important considerations for proper installation of temperature sensors. The tables below provide tolerances on these key dimensions of Watlow® catalog sensor products.

General Application and RTD Sheath Tolerances		
Sheath Diameter (in.)	**Diameter Tolerance (in.)**	**Length Tolerance (in.)**
/	± 0.003	± 0.125
/	± 0.003	± 0.125
/	± 0.003	± 0.125
/	± 0.003	± 0.250

Mineral Insulated (MI) Thermocouple Sheath Tolerances			
Diameter (in.)	**Diameter Tolerance (in.)**	**Length Tolerance (in.)**	
		up to 24 in.	**over 24 in.**
0.020	+ 0.001 - 0.0005	± 0.25	± 1%
0.032	+ 0.001 - 0.0005	± 0.25	± 1%
0.040	+ 0.001 - 0.0005	± 0.25	± 1%
0.063	+ 0.001 - 0.001	± 0.125	± ½%
0.125	+ 0.002 - 0.001	± 0.125	± ½%
0.188	+ 0.002 - 0.001	± 0.125	± ½%
0.250	+ 0.003 - 0.001	± 0.125	± ½%

Flexible Lead Tolerances

General Application, MI Thermocouple and RTD Lead Length	
Lead Length (in.)	**Tolerance (in.)**
Under 6	+ 1 - 0
6 to 24	+ 2 - 0
Over 24 to 120	+ 6 - 0
Over 120	+ 5% - 0

Note: Strip length tolerances ±1/8 inch.

Sheath Configuration

Standard shipping methods and element strength require that long length mineral insulated sensors be shipped in coil format. This chart provides the standard sheath configuration by diameter.

MI Thermocouple Standard Sheath Configuration

Sheath Diameter in.	Standard Length in.	Configuration
0.020	Up to 20	Straight
0.032	From 20 to 170 170 to 300 Greater than 300	3 in. coil 6 in coil 9 - 10 in. coil
0.040	Up to 20 From 20 to 120 120 to 200 Greater than 200	Straight 3 in. coil 6 in coil 9 - 10 in. coil
0.063	Up to 50 50 to 540 (45 feet) Greater than 540 (45 feet)	Straight 9 - 10 in. coil 24 in. coil
0.125 0.188 0.250	Up to 96 Greater than 96	Straight 24 in. coil

Metal Substitution

On standard catalog items, Watlow reserves the right to substitute superior materials of construction without notification. These can include, but are not limited to, superior metals and special limits of error wire.

Initial Accuracy of Temperature Sensors

Industry specifications establish the accuracy limits of industrial temperature sensors. These limits define initial sensor performance at the time of manufacture. Time, temperature and environmental operating conditions may cause sensors to change during use. Also, consider that overall system accuracy will depend on the instrument and other installation parameters.

Thermocouples — Tolerances on Initial Values of Electromotive Force vs. Temperature

Reference Junction 32°F (0°C)

Calibration Type	Temperature Range °F	Temperature Range (°C)	Tolerances (whichever is greater) Standard °F	Standard (°C)	Special °F	Special (°C)
Thermocouples ① ③						
B	1600 to 3100	(870 to 1700)		±0.5%		±0.25%
E	32 to 1600	(0 to 870)	②	(±1.7 or ±0.5%)	②	(±1.0 or ±0.4%)
J	32 to 1400	(0 to 760)	②	(±2.2 or ±0.75%)	②	(±1.1 or ±0.4%)
K or N	32 to 2300	(0 to 1260)	②	(±2.2 or ±0.75%)	②	(±1.1 or ±0.4%)
R or S	32 to 2700	(0 to 1480)	②	(±1.5 or ±0.25%)	②	(±0.6 or ±0.1%)
T	32 to 700	(0 to 370)	②	(±1.0 or ±0.75%)	②	(±0.5 or ±0.4%)
E[d]	-328 to 32	(-200 to 0)	②	(±1.7 or ±1%)	②	⑤
K[d]	-328 to 32	(-200 to 0)	②	(±2.2 or ±2%)	②	⑤
T[d]	-328 to 32	(-200 to 0)	②	(±1.0 or ±1.5%)	②	⑤
Extension Wires ⑥ ⑦						
EX	32 to 400	(0 to 200)	±3.0	(±1.7)	±1.8	(±1.0)
JX	32 to 400	(0 to 200)	±4.0	(±2.2)	±2.0	(±1.1)
KX or NX	32 to 400	(0 to 200)	±4.0	(±2.2)	±2.0	(±1.1)
TX	32 to 200	(0 to 100)	±1.8	(±1.0)	±0.9	(±0.5)
Compensating Extension Wires ⑧ ⑨						
RX, SX	32 to 400	(0 to 200)	±9.0	(±5.0)	*	*

① Tolerances in this table apply to new, essentially homogeneous thermocouple wire, normally in the size range 0.25 to 3 mm in diameter (No. 30 to No. 8 AWG) and used at temperatures not to exceed the recommended limits shown above. If used at higher temperatures, these tolerances may not apply.

② At a given temperature that is expressed in °C, the tolerance expressed in °F is 1.8 times larger than the tolerance expressed in °C. Note: Wherever applicable, percentage-based tolerances must be computed from temperatures that are expressed in °C.

③ **Caution**: Users should be aware that certain characteristics of thermocouple materials, including the EMF vs. 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 provided above apply only to new wire as delivered to the user and do not allow for changes in characteristics with use. The magnitude of changes will depend on factors such as wire size, temperature, time of exposure and environment. Further noted that due to possible changes in homogeneity, attempting to recalibrate 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 known good thermocouples to ascertain their suitability for further service under conditions of comparison.

④ Thermocouples and thermocouple materials are normally supplied to meet tolerances specified in the table for temperatures above 0°C. The same materials, however, may not fall within the tolerances given for temperatures below °C in the second section of the table. Materials required to meet tolerances stated for temperatures below 0°C must be stated in the purchase order. Selection of materials will usually be required.

⑤ Special tolerances for temperatures below 0°C are difficult to justify due to limited available information. However, the following values for Types E and T thermocouples are suggested as a guide for discussion between purchaser and supplier: Type E: -200 to 0°C ±1.0°C or ±0.5 percent (whichever is greater); Type T: -200 to 0°C ±0.5 or±0.8 percent (whichever is greater).

Initial values of tolerance for Type J thermocouples at temperatures below 0°C, and special tolerances for Type K thermocouples below 0°C, are not given due to characteristics of the materials.

⑥ Tolerances shown in the table represent the maximum error contribution allowable from new and essentially homogeneous thermocouple extension wire when exposed to the full temperature range shown above. Extension grade materials are not intended for use outside of the temperature range shown.

⑦ Thermocouple extension wire contributes to the total thermoelectric signal that depends on the temperature difference between the extreme ends of the extension wire length. The actual magnitude of any error introduced into a measuring circuit by homogeneous and correctly connected extension wires is equal to the algebraic difference of the deviations at its two end temperatures, as determined for that extension wire pair.

⑧ Tolerances in the table apply to new and essentially homogeneous thermocouple compensating extension wire when used at temperatures within the range shown above.

⑨ Thermocouple compensating extension wire contributes to the total thermoelectric signal that depends on the temperature difference between the extreme ends of the compensating extension wire length.

* Special tolerance grade compensating extension wires are not available.

Initial Accuracy of Temperature Sensors *(Continued)*

Generally, if accuracy is the most important concern and the application temperature is between 284°F and 1202°F (140°C and 650°C), RTDs are the best choice.

Resistance Temperature Detectors—RTDs

Table of Tolerance Values

Temperature °C	Resistance Value Ω	Tolerance DIN-IEC.751	
		Class A °C (Ω)	Class B °C (Ω)
-200	18.52	±0.55 (±0.24)	±1.3 (±0.56)
-100	60.26	±0.35 (±0.14)	±0.8 (±0.32)
0	100.00	±0.15 (±0.06)	±0.3 (±0.12)
100	138.51	±0.35 (±0.13)	±0.8 (±0.30)
200	175.86	±0.55 (±0.20)	±1.3 (±0.48)
300	212.05	±0.75 (±0.27)	±1.8 (±0.64)
400	247.09	±0.95 (±0.33)	±2.3 (±0.79)
500	280.98	±1.15 (±0.38)	±2.8 (±0.93)
600	313.71	±1.35 (±0.43)	±3.3 (±1.06)
650	329.64	±1.45 (±0.46)	±3.6 (±1.13)

Where **t** is the actual temperature, in °C, of the platinum elements.

RTD Tolerance Class Definitions

DIN class A:±[0.15 + 0.002 |t|]°C

DIN class B:±[0.30 + 0.005 |t|]°C

Three-wire is most common, but four-wire provides higher system accuracy.