

REFERENCE DATA ON THERMOCOUPLE & PLATINUM RESISTANCE THERMOMETRY

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REFERENCE DATA ON THERMOCOUPLE THERMOMETRY

Thermocouple Accuracies

Tolerance classes for thermocouples to IEC 584-2: 1982.

Fe-Con (J)	Class 1	- 40 +750°C:	$\pm 0.004 \cdot t$	or $\pm 1.5^\circ\text{C}$
	Class 2	- 40 +750°C:	$\pm 0.0075 \cdot t$	or $\pm 2.5^\circ\text{C}$
	Class 3	- -	-	
Cu-Con (T)	Class 1	- 40 +350°C:	$\pm 0.004 \cdot t$	or $\pm 0.5^\circ\text{C}$
	Class 2	- 40 +350°C:	$\pm 0.0075 \cdot t$	or $\pm 1.0^\circ\text{C}$
	Class 3	-200 + 40°C:	$\pm 0.015 \cdot t$	or $\pm 1.0^\circ\text{C}$
NiCr -Ni (K) and NiCrSi-NiSi (N)	Class 1	- 40 +1000°C:	$\pm 0.004 \cdot t$	or $\pm 1.5^\circ\text{C}$
	Class 2	- 40 +1200°C:	$\pm 0.0075 \cdot t$	or $\pm 2.5^\circ\text{C}$
	Class 3	-200 + 40°C:	$\pm 0.015 \cdot t$	or $\pm 2.5^\circ\text{C}$
NiCr-Con (E)	Class 1	- 40 +800°C:	$\pm 0.004 \cdot t$	or $\pm 1.5^\circ\text{C}$
	Class 2	- 40 +900°C:	$\pm 0.0075 \cdot t$	or $\pm 2.5^\circ\text{C}$
	Class 3	-200 + 40°C:	$\pm 0.015 \cdot t$	or $\pm 2.5^\circ\text{C}$
Pt10Rh-Pt (S) and Pt13Rh-Pt (R)	Class 1	0 +1600°C:	$\pm [1+(t-1000) \cdot 0.003]$	or $\pm 1.0^\circ\text{C}$
	Class 2	- 40 +1600°C:	$\pm 0.0025 \cdot t$	or $\pm 1.5^\circ\text{C}$
	Class 3	- -	-	
Pt30Rh- Pt6Rh (B)	Class 1	- -	-	
	Class 2	+600 +1700°C:	$\pm 0.0025 \cdot t$	or $\pm 1.5^\circ\text{C}$
	Class 3	+600 +1700°C:	$\pm 0.005 \cdot t$	or $\pm 4.0^\circ\text{C}$

Note: t = actual temperature

Use the larger of the two deviation values.

Base Metal Extension and Compensating Wires and Cable Types and Tolerances

Thermocouple Wire Types and Codes IEC 584-3: 1989

Thermocouple Type	Conductors +/-	Cable Code
E	Nickel Chromium/Constantan (Nickel Chromium/Copper-Nickel, Chromel/Constantan, T1/Advance, NiCr/Constantan)	EX
J	Iron*/Constantan (Iron/Copper-Nickel, Fe/Konst, Iron/Advance, Fe/Constantan, I/C)	JX
K	Nickel Chromium/Nickel Aluminium* (NC/NA, Chromel/Alumel, C/A, T1/T2 NiCr/Ni, NiCr/NiAl)	KX
N	Nicrosil/Nisil	NX NC
T	Copper/Constantan (Copper/Copper-Nickel, Cu/Con, Copper/Advance)	TX
Vx	Copper/Constantan (Low Nickel) (Cu/Constantan) Compensating for "K" (Cu/Constantan)	KCB
U	Copper/Copper Nickel, Compensating for Platinum 10% or 13% Rhodium/Platinum (Codes S and R respectively) Copper/Cupronic, Cu/CuNi, Copper/No.11 Alloy)	RCA SCA

*Magnetic () Alternative & Trade Names

Identification as to whether a thermocouple cable type is extension or compensating is indicated in the example which follows; however, please note that a letter A or B after the C for Compensating refers to the Cable Temperature Range in accordance with the Table of Tolerance Values set out in this standard.

K X 1 = K EXTENSION CLASS 1

K CA 2 = K COMPENSATING CLASS 2 0 to 150°

Table of Thermocouple Wire Tolerances

The figures shown in the tables are those appropriate to the measuring junction temperatures in the final column. In most cases the error expressed in degrees Celsius will be larger at lower thermocouple junction temperatures.

Type	Tolerance Class		Cable Temperature range	Measuring junction temperature
	1	2		
JX	$\pm 85\mu\text{V}(\pm 1.5^\circ\text{C})$	$\pm 140\mu\text{V}(\pm 2.5^\circ\text{C})$	-25°C to $+200^\circ\text{C}$	500°C
TX	$\pm 30\mu\text{V}(\pm 0.5^\circ\text{C})$	$\pm 60\mu\text{V}(\pm 1.0^\circ\text{C})$	-25°C to $+100^\circ\text{C}$	300°C
EX	$\pm 120\mu\text{V}(\pm 1.5^\circ\text{C})$	$\pm 200\mu\text{V}(\pm 2.5^\circ\text{C})$	-25°C to $+200^\circ\text{C}$	500°C
KX	$\pm 60\mu\text{V}(\pm 1.5^\circ\text{C})$	$\pm 100\mu\text{V}(\pm 2.5^\circ\text{C})$	-25°C to $+200^\circ\text{C}$	900°C
NX	$\pm 60\mu\text{V}(\pm 1.5^\circ\text{C})$	$\pm 100\mu\text{V}(\pm 2.5^\circ\text{C})$	-25°C to $+200^\circ\text{C}$	900°C
KCA	-	$\pm 100\mu\text{V}(\pm 2.5^\circ\text{C})$	0°C to $+150^\circ\text{C}$	900°C
KCB	-	$\pm 100\mu\text{V}(\pm 2.5^\circ\text{C})$	0°C to $+100^\circ\text{C}$	900°C
NC	-	$\pm 100\mu\text{V}(\pm 2.5^\circ\text{C})$	0°C to $+150^\circ\text{C}$	900°C
RCA	-	$\pm 30\mu\text{V}(\pm 2.5^\circ\text{C})$	0°C to $+100^\circ\text{C}$	1000°C
RCB	-	$\pm 60\mu\text{V}(\pm 5.0^\circ\text{C})$	0°C to $+200^\circ\text{C}$	1000°C
SCA	-	$\pm 30\mu\text{V}(\pm 2.5^\circ\text{C})$	0°C to $+100^\circ\text{C}$	1000°C
SCB	-	$\pm 60\mu\text{V}(\pm 5.0^\circ\text{C})$	0°C to $+200^\circ\text{C}$	1000°C

Notes:

1. Cable temperature range may be restricted to figures lower than those shown in the table because of temperature limitations imposed by the insulant.
2. A cable comprising two copper conductors may be used with type B thermocouples. The expected maximum additional deviation within the cable temperature range 0°C to $+100^\circ\text{C}$ is $40\mu\text{V}$. The equivalent in temperature is 3.5°C when the measuring junction of the thermocouple is at 1400°C .

Wire and Cable Data

Thermocouple Wire

Twin, single conductor, having a temperature / e.m.f. relationship to the appropriate standard over the complete temperature range.

Extension Cable

Twin, stranded conductors for connection between measuring thermocouple and instrument (or external reference junction) of the same materials as the thermocouple and having the same e.m.f. / temperature characteristics over a temperature range limited by the insulation material.

Compensating Wire or Cable

Twin, single or standard conductors for connection between measuring thermocouple and instrument (or external reference junction) of different composition from the thermocouple material, but having similar e.m.f / temperature characteristics over a limited temperature range. Types U and Vx in Conductors Table.

Connection of Thermocouples to Measuring Instruments

Ordinary copper wires should never be used, as the error will be equal to the difference in temperature between the connecting point of the thermocouple and the instrument (or external reference junction).

Extension or compensating wire or cable must be employed, and it is essential that the same polarity is maintained. If the polarity is reversed, the error is equal to twice the temperature difference between the connecting point of the thermocouple and the instrument (or external reference junction). For maximum accuracy extension cables should be used, and the terminals and connectors should be of thermocouple materials to maintain continuity.

Single / Multi-strand

The choice is mainly determined by the application (e.g. termination considerations and internal diameter of associated sheath). Generally, single strand wires are used for hot junctions, and multistrand for extensions of the thermocouple as being more flexible. The greater the effective conductor diameter, the lower the value of thermocouple loop resistance; an important consideration with long cable runs.

Conductor Size Equivalent (diameter)

No.	SWG		B&S (AWG)		No	SWG		B&S(AWG)	
	inches	mm	inches	mm		inches	mm	inches	mm
0	0.324	8.23	0.3249	8.25	26	0.018	0.457	0.0159	0.404
1	0.300	7.62	0.2893	7.35	27	0.0164	0.417	0.0142	0.361
2	0.276	7.01	0.2576	6.54	28	0.0148	0.376	0.0126	0.320
3	0.252	6.40	0.2294	5.83	29	0.0136	0.345	0.0113	0.287
4	0.232	5.89	0.2043	5.19	30	0.0124	0.315	0.0100	0.254
5	0.212	5.38	0.1819	4.62	31	0.0116	0.295	0.0089	0.226
6	0.192	4.88	0.1620	4.11	32	0.0108	0.274	0.0080	0.203
7	0.176	4.47	0.1443	3.67	33	0.0100	0.254	0.0071	0.180
8	0.160	4.06	0.1285	3.26	34	0.0092	0.234	0.0063	0.160
9	0.144	3.66	0.1144	2.91	35	0.0084	0.213	0.0056	0.142
10	0.128	3.25	0.1019	2.59	36	0.0076	0.193	0.0050	0.127
11	0.116	2.95	0.0907	2.30	37	0.0068	0.173	0.0045	0.114
12	0.104	2.64	0.0808	2.05	38	0.0060	0.152	0.0040	0.102
13	0.092	2.34	0.0720	1.83	39	0.0052	0.132	0.0035	0.089
14	0.080	2.03	0.0641	1.63	40	0.0048	0.122	0.0031	0.079
15	0.072	1.83	0.0571	1.45	41	0.0044	0.112	0.0028	0.071
16	0.064	1.63	0.0508	1.29	42	0.0040	0.102	0.0025	0.064
17	0.056	1.42	0.0453	1.15	43	0.0036	0.091	0.0022	0.056
18	0.048	1.22	0.0403	1.02	44	0.0032	0.081	0.0020	0.051
19	0.040	1.02	0.0359	0.912	45	0.0028	0.071	0.0018	0.046
20	0.036	0.914	0.0320	0.813	46	0.0024	0.061	-	-
21	0.032	0.813	0.0285	0.724	47	0.0020	0.051	-	-
22	0.028	0.711	0.0253	0.643	48	0.0016	0.041	-	-
23	0.024	0.610	0.0226	0.574	49	0.0012	0.030	-	-
24	0.022	0.559	0.0201	0.511	50	0.0010	0.025	-	-
25	0.020	0.508	0.0179	0.455					

SWG = (BRITISH) STANDARD WIRE GAUGE

B&S = BROWN AND SHARPE

AWG = AMERICAN WIRE GAUGE

Conductor Cross Sectional Areas

Metric	mm ²	SWG	AWG	Single Strand	
				dia. inches	dia. mm
1/0.2	0.032	-	32	0.0080	0.20
1/0.315	0.078	30	-	0.0124	0.31
1/0.508	0.203	25	-	0.0200	0.51
7/0.2	0.219	-	-	0.0206	0.52
14/0.2	0.412	-	21	0.0285	0.72

Insulated Wire Sizes (Subject to variation)

Sizes in mm

Insulation	Wire Size Insulated Conductor	Each Sheath	Overall
PVC			
Figure of 8	1/0.508	-	1.4 x 2.7
Flat Pair	7/0.2	1.7	3.4 x 4.8
Flat Pair	13/0.2	1.9	3.4 x 5.1
Flat Pair	23/0.2	2.0	3.5 x 5.5
PTFE			
Twisted Pair	1/0.2	0.6	
Twisted Pair	1/0.315	0.7	
Twisted Pair	1/0.508	0.8	
Flat Pair	1/0.315	0.6	1.3 x 1.9
Flat Pair	7/0.2	0.9	5.5 x 2.4
GLASSFIBRE			
Flat Pair	1/0.2	0.5	1.0 x 1.4
Flat Pair	1/0.315	0.7	1.1 x 1.7
Flat Pair	1/0.508	0.8	1.3 x 2.0
Flat Pair	7/0.2	0.8	1.1 x 1.9
Flat Pair	14/0.2	1.0	1.3 x 2.2
GLASSFIBRE & S.S. OVERBRAID			
	7/0.2	0.9	1.6 x 2.4

Loop Resistance, Ohms per Combined Metre Approximate (Sizes in mm)

Code	1/0.2	1/0.315	1/0.508	7/0.2	13/0.2	14/0.2	23/0.2
E	38.1	15.4	5.9	5.3	2.9	2.7	1.6
J	19.3	7.8	3.0	2.7	1.5	1.4	0.8
K	31.8	12.8	4.9	4.5	2.4	2.2	1.4
N	44.2	17.7	6.8	6.2	3.4	3.2	1.9
T	16.2	6.5	2.5	2.3	1.2	1.1	0.7
U	1.4	0.6	0.2	0.2	0.1	0.1	0.1
VX	16.2	6.5	2.5	2.3	1.2	1.1	0.7

PLATINUM RESISTANCE THERMOMETRY

Tolerances for Pt100 Thermometers to IEC 751: 1983

Temp (°C)	Resistance (Ω)	Tolerance			
		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
700	345.28	–	–	3.8	1.17
800	375.70	–	–	4.3	1.28
850	390.48	–	–	4.6	1.34

Connection Configurations and Termination Colour Codes

