Thermoelectric Alloy Property Data

ALLOY or DESIGNATION	Notes	PERCENT PURITY or composition	RESISTIVITY Ω cmil/ft (at 0°C)		TEMP COEEF. OF RESISTANCE (0-100°C)		TENSILE STRENGTH (psi x 1000)		ELONGATION (percent)		Melting point °C	Density (g/cm³)
			Hard	Annld	Hard	Annld	Hard	Annld	Hard	Annld		
Pure Metals												
Iron		99.9+%	66	60	.0062	.0065	90	34	2	40	1536	7.9
Nickel		99.98%	39	37	.0064	.0068	100	48	2	36	1452	8.9
Molybdenum		99.9+%	42	31	.0036	.0047	250	120	2	16	2610	10.2
Aluminum (H-P)		99.99+%	17.4	15	.0038	.0044	16.3	6.8	5	60	660	2.71
Copper		99.98%	9.44	9.24	.0041	.0043	76	32	1.5	46	1083	8.93
Gold		99.999%	13.4	13.17	.0039	.0040	46	19	1.5	36	1063	19.30
Silver		99.99%	9.3	8.83	.0038	.0041	52	24	1.5	46	960.8	10.5
Tungsten		99.99%	42	33	.0036	.0048	285	80	-	3	3410	19.3
Rhenium		99.99%	-	117	-	-	360	170	-	10	3170	20.0
Platium Ref		99.999+%	61.2	59.13	.00386	.00393	60	24	2	38	1769	21.45
Rhodium		99.99%	33.0	25.8	.0029	.0046	275	120	2	16	1966	12.42
Platinum												
Pt- 6%Rh		94%Pt- 6%Rh	101	95	.0019	.0020	85	37	1.5	34	1810	20.51
Pt-10%Rh		90% Pt-10% Rh	114	111	.0016	.0017	95	46	1.5	32	1830	19.95
Pt-13% Rh		87% Pt-13% Rh	119	114	.0015	.0016	105	48	1.5	32	1840	19.55
Pt-20% Rh		80% Pt-20% Rh	124	116	.0013	.0014	140	72	1.5	32	1870	18.65
Pt-30% Rh		70% Pt-30% Rh	116	112	.0013	.0014	160	74	1.5	26	1910	17.52
Pt-40% Rh		60% Pt-40% Rh	108	101	.0013	.0014	190	78	1.5	26	1920	16.54
Nickel Alloys												
Constantan		55% Cu-45% Ni	315	294	.00003	.00002	150	80	2	32	1270	8.86
CHROMEGA® P		90% Ni-10% Cr	-	425	.00032	.00032	165	95	2	27	1430	8.73
ALOMEGA®		95% Ni-2% Mn-2% Al	-	177	.00188	.00188	170	85	2	32	1400	8.60
Tungsten Alloys												
Tungsten-3% Re		97% W- 3% Re	-	55	-	-	320	180	-	10	3410	19.4
Tungsten-5% Re		95% W- 5% Re	-	70	-	-	320	200	-	10	3350	19.4
Tungsten-25% Re		75% W-25% Re	-	165	-	-	300	210	-	10	3130	19.7
Tungsten-26% Re		74% W-26% Re	-	170	-	-	300	200	-	10	3120	19.7
Compensating Alloys												
Alloy #11	(1)	Pt alloys	-	30	-	.0014	105	50	2	30	1090	8.91
Alloy #200		Tungsten	-	470	-	-	-	-	-	-	1430	8.73
Alloy #203		Tungsten- 3% Re	-	470	-	.0003	-	-	-	-	1400	8.60
Alloy #205		Tungsten- 5% Re	-	510	-	-	-	-	-	-	1410	8.58
Alloy #225		Tungsten-25% Re	-	180	-	.0012	-	-	-	-	1370	8.88
Alloy #226		Tungsten-26% Re	-	160	-	-	-	-	-	-	1450	8.85
Alloy #260		Tungsten-26% Re	-	750	-	-	-	-	-	-	1520	7.42

1. "Percent purity or composition" column refers to matching thermocouple grade alloy.

Changes in Thermocouple Resistance with Increasing Temperature

N=Neg P=Pos Thermoelements	Ratio of Resistance at Temperature Indicated to Resistance at 0°C (32°F)									
	0°C (32°F)	20°C (68°F)	200°C (392°F)	400°C (752°F)	600°C (1112°F)	800°C (1472°F)	1000°C (1832°F)	1200°C (2192°F)	1400°C (2552°F)	1500°C (2732°F)
JP	1.00	1.13	2.46	4.72	7.84	12.0	13.07	…	…	…
JN, TN, EN	1.00	0.999	0.996	0.994	1.02	1.056	1.092	…	…	…
TP	1.00	1.11	1.86	2.75	3.70	4.75	5.96	…	…	…
KP, EP	1.00	1.01	1.09	1.19	1.25	1.30	1.37	1.43	…	…
KN	1.00	1.05	1.43	1.64	1.82	1.98	2.15	2.32	…	…
NP	1.00	1.01	1.02	1.07	1.08	1.08	1.10	…	…	…
NN	1.00	1.07	1.13	1.27	1.39	1.55	1.68	…	…	…
RP	1.00	1.03	1.31	1.60	1.89	2.16	2.41	2.66	2.90	3.01
SP	1.00	1.03	1.33	1.65	1.95	2.23	2.50	2.76	3.01	3.13
RN, SN	1.00	1.06	1.77	2.50	3.18	3.81	4.40	4.94	5.42	5.66
BP	1.00	1.03	1.26	1.51	1.76	1.98	2.20	2.41	2.62	2.73
BN	1.00	1.03	1.40	1.78	2.14	2.47	2.78	3.08	3.37	3.51

N=Neg, P=Pos	Resistance of Thermocouples, ohms per foot at 20°C (68°F)											
Awg. No.	Diameter in.	KN	KP,EP	TN,JN,EN	TP	JP	NP	NN	RN, SN	RP	SP	BP	BN
16	0.0508	0.0683	0.164	0.1113	0.00402	0.0276	.2230	.08458	0.0247	0.0456	0.0445	0.0447	0.0414
20	0.0320	0.173	0.415	0.287	0.0102	0.0699	.5664	.2148	0.0624	0.1149	0.1125	0.1130	0.1046
24	0.0201	0.438	1.05	0.728	0.0257	0.1767	1.436	.5445	0.1578	0.4656	0.2847	0.2859	0.2647
30	0.0100	1.77	4.25	2.94	0.1032	0.710	5.800	2.20	0.6344	2.965	1.144	1.149	1.064
36	0.0050	7.08	17.0	11.8	0.4148	2.86	23.20	8.800	2.550	12.25	4.600	4.620	4.277

Thermocouple Types

Iron-Constantan (ANSI Symbol J) The Iron-Constantan "J" curve thermocouple with a positive iron wire and a negative Constantan wire is recommended for reducing atmospheres. The operating range for this alloy combination is 1600°F for the largest wire sizes. Smaller size wires should operate in correspondingly lower temperatures.

Copper-Constantan (ANSI Symbol T) The Copper-Constantan "T" curve thermocouple, with a positive copper wire and a negative Constantan wire, is recommended for use in mildly oxidizing and reducing atmospheres up to 750°F. They are suitable for applications where moisture is present. This alloy is recommended for low temperature work since the homogeneity of the component wires can be maintained better than with other base metal wires. Therefore, errors due to inhomogeneity of wires in zones of temperature gradients are greatly reduced.

CHROMEGA®-ALOMEGA® (ANSI Symbol K) The CHROMEGA®-ALOMEGA® "K" curve thermocouple with a positive CHROMEGA® wire and a negative ALOMEGA® wire is recommended for use in clean oxidizing atmospheres, The operating range for this alloy is 2300°F for the largest wire sizes. Smaller wire sizes should operate in correspondingly lower temperatures.

CHROMEGA®-Constantan (ANSI Symbol E) The CHROMEGA®-Constantan thermocouple may be used for temperatures up to 1600°F in a vacuum or inert, mildly oxidizing or reducing atmosphere. At sub-zero temperatures, the thermocouple is not subject to corrosion. This thermocouple has the highest emf output of any standard metallic thermocouple.

Platinum-Rhodium Alloys (ANSI Symbols S, R and B) Three types of "noble-metal" thermocouples are in common use; they are: 1) a positive wire of 90% platinum and 10% rhodium used with a negative wire of pure platinum, 2) a positive wire of 87% platinum and 13% rhodium used with a negative wire of pure platinum, and 3) a positive wire of 70% platinum and 30% rhodium used with a negative wire of 94% platinum and 6% rhodium. They have a high resistance to oxidation and corrosion. However, hydrogen, carbon and many metal vapors can contaminate a platinum-rhodium thermocouple. The recommended operating range for the platinum-rhodium alloys is 2800°F, although temperatures as high as 3270°F can be measured with the Pt-30% Rh vs. Pt-6% Rh alloy combination.

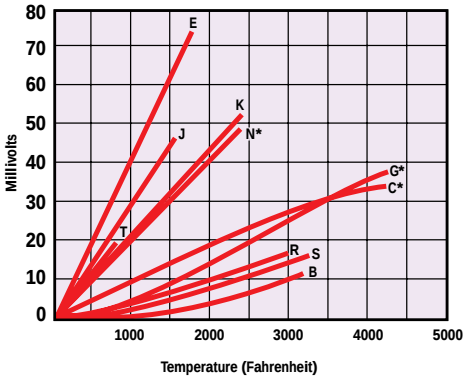
Tungsten-Rhenium Alloys Three types of tungsten-rhenium thermocouples are in common use for measuring temperatures up to 5000°F. These alloys have inherently poor oxidation resistance and should be used in vacuum, hydrogen or inert atmospheres.

Trade Names of Alloys

ANSI DESIGNATION	ALLOY (Generic or Trade Names)
JP	Iron
JN, EN, or TN	Constantan, Cupron, Advance
KP or EP	CHROMEGA®, Tophel, T_1, Thermokanthal KP
KN	ALOMEGA®, Nial, T_2, Thermokanthal KN
TP	Copper
RN or SN	Pure Platinum
RP	Platinum 13% Rhodium
SP	Platinum 10% Rhodium

Trade Names: Advance T - Driver Harris Co., CHROMEGA® and ALOMEGA® - OMEGA Engineering, Inc., Cupron, Nial and Trophel -Wilbur B. Driver Co., Thermokanthal KP and Thermokanthal KN -The Kanthal Corporation.

ANSI LETTER DESIGNATIONS -Currently thermocouple and extension wire is ordered and specified by an ANSI letter designation. Popular generic and trade name examples are CHROMEGA®/ALOMEGA® -ANSI Type K: Iron/Constantan - ANSI Type J: Copper/Constantan - ANSI Type T CHROMEGA®/Constantan -ANSI Type E: Platinum/Platinum 10% Rhodium - ANSI Type S: Platinum/Platinum 13% Rhodium -ANSI Type R. The positive and negative legs are identified by letter suffixes P and N, respectively, as listed in the tables.



ANSI Symbol

T Copper vs. Constantan
E CHROMEGA® vs. Constantan
J Iron vs. Constantan
K CHROMEGA® vs. ALOMEGA®
N* OMEGALLOY® Nicrosil-Nisil
G* Tungsten vs. Tungsten 26% Rhenium
C* Tungsten 5% Rhenium vs. Tungsten 26% Rhenium
D* Tungsten 3% Rhenium vs. Tungsten 25% Rhenium
R Platinum 13% Rhodium vs. Platinum
S Platinum 10% Rhodium vs. Platinum
B Platinum 30% Rhodium vs. Platinum 6% Rhodium

*Not an ANSI Symbol

Resistance Vs. Wire Diameter

AWG No.	Diameter inches	Type K CHROMEGA® ALOMEGA®	Type J Iron/ Constantan	Type T Copper/ Constantan	Type E CHROMEGA® Constantan	Type S Pt/ PT110%Rh	Type R Pt/ PT113%Rh	Type RX/SX Copper Alloy11**	Type C† W5%Re/ W26%Re	Type CX Alloy 405 Alloy 426	Type G† W/ W26%Re	Type D† W3%Re/ W25%Re	Type BX Copper/ Copper*
6	0.162	0.023	0.014	0.012	0.027	0.007	0.007	0.003	0.009	0.014	0.008	0.009	0.000790
8	0.128	0.037	0.022	0.019	0.044	0.011	0.011	0.004	0.015	0.023	0.012	0.015	0.001256
10	0.102	0.058	0.034	0.029	0.069	0.018	0.018	0.007	0.023	0.037	0.020	0.022	0.001998
12	0.081	0.091	0.054	0.046	0.109	0.028	0.029	0.011	0.037	0.058	0.031	0.035	0.00318
14	0.064	0.146	0.087	0.074	0.175	0.045	0.047	0.018	0.058	0.093	0.049	0.055	0.00505
16	0.051	0.230	0.137	0.117	0.276	0.071	0.073	0.028	0.092	0.146	0.078	0.088	0.00803
18	0.040	0.374	0.222	0.190	0.448	0.116	0.119	0.045	0.148	0.238	0.126	0.138	0.01277
20	0.032	0.586	0.357	0.298	0.707	0.185	0.190	0.071	0.235	0.371	0.200	0.220	0.02030
24	0.0201	1.490	0.878	0.7526	1.78	0.464	0.478	0.180	0.594	0.941	0.560	0.560	0.05134
26	0.0159	2.381	1.405	1.204	2.836	0.740	0.760	0.288	0.945	1.503	0.803	0.890	0.08162
30	0.0100	5.984	3.551	3.043	7.169	1.85	1.91	0.727	2.38	3.800	2.03	2.26	0.2064
32	0.0080	9.524	5.599	4.758	11.31	1.96	3.04	1.136	3.8	5.94	3.22	3.60	0.3282
34	0.0063	15.17	8.946	7.66	18.09	4.66	4.82	1.832	6.04	9.57	5.10	5.70	0.5218
36	0.0050	24.08	14.20	12.17	28.76	7.40	7.64	2.908	9.6	15.20	8.16	9.10	0.8296
38	0.0039	38.20	23.35	19.99	45.41	11.6	11.95	4.780	15.3	24.98	12.9	15.3	1.3192
40	0.00315	60.88	37.01	31.64	73.57	18.6	19.3	7.327	24.4	38.30	20.6	23.0	2.098
44	0.0020	149.6	88.78	76.09	179.20	74.0	76.5	18.18	60.2	95.00	51.1	56.9	5.134
50	0.0010	598.4	355.1	304.3	716.9	185	191	72.7	240	380.0	204	227	20.64
56	0.00049	2408	1420	1217	2816	740	764	302.8	1000	1583	850	945	86.38

**Increase the resistance by 19% for nickel plated, type RTD wire* ***Maximum Resistance of reviewed wire* *†Not ANSI symbol*

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