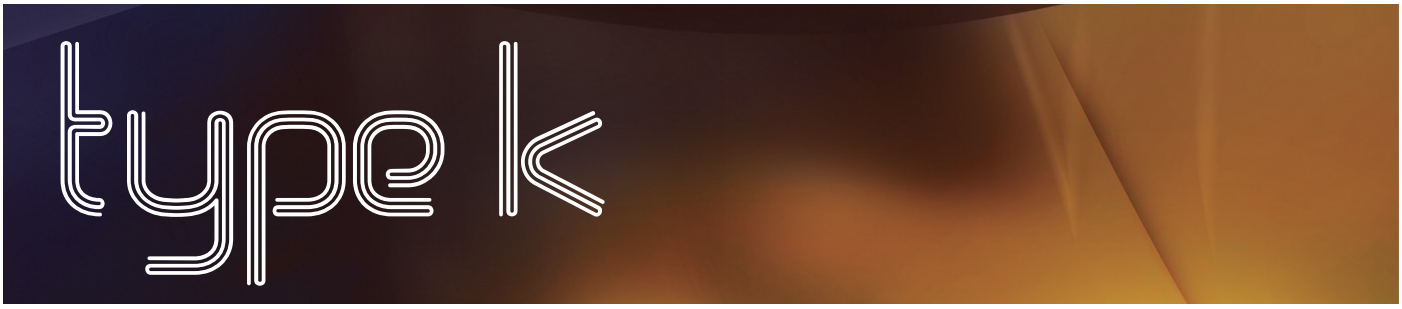
Thermocouple Alloys



Type K is the most commonly used thermocouple for measuring high temperatures, providing the widest operating temperature range from – 200 ° to + 1260 °C. It usually works in most applications, which include industrial heat treatments, processing operations, precision laboratory and research work, and some of the most demanding applications from nuclear reactors and submarines, to jet aircraft engines. Type K is particularly appreciated due to its accuracy and reliability at high temperatures.

1. Chemical composition and mechanical properties

Alloy	Chemical composition			Melting point °C	Resistivity	Density g/cm³	Temp. coef. of resistance (x10-6/°C)	Linear expansion (coef. x10-6/°C)	Thermal Conductivity (W m-1 °C-1 at 20°C)
	Ni	Cr	Others						
KP (+)	90	10	-	1430	70	8.72	300	17	19.2
KN (-)	94	-	Cu 2.20 - Si 2.60- Others +	1400	29	8.60	1900	17	29.7

Resistivity: micro ohm-cm at 20°C - Temperature coefficient and linear expansion coefficient by °C from 20 up to 100°C.

2. Maximum operating temperatures

Thermocouple operating conditions are very different from one to another. Precise instructions cannot be given on lifetime at various temperatures. The table shown below is to be used as a guideline to reach an acceptable lifetime. Reaction to temperature variation are faster with a smaller diameter, but to the detriment of the lifetime of the thermocouple.
Please note that the data below are given as indicative values.

As per norm ASTM

Thermocouple	Dia 3.20 mm	Dia 1.60 mm	Dia 0.81 mm	Dia 0.51 mm	Dia 0.25 mm
KP - KN	1260 ° C	1090° C	980° C	870° C	760° C

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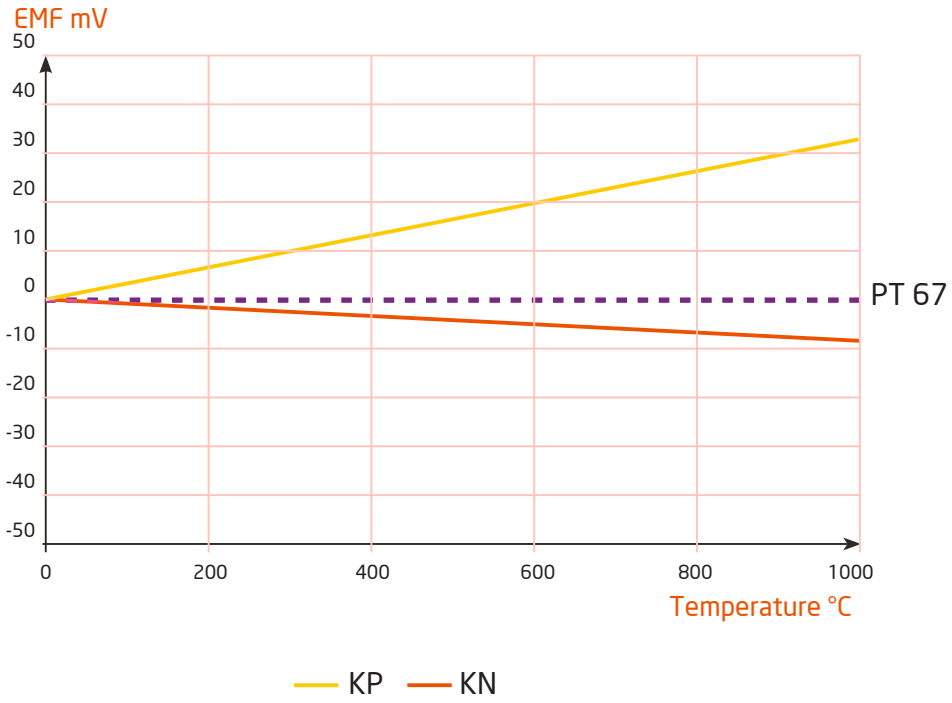
3. KP and KN vs platinum

Nominal EMF for type K thermocouple vs Pt 67*



** For extension cables EMF values: please refer to thermocouple graphics until 200°C*

4. EMF calculation of a couple

The table below indicates the standard EMF of a couple for any given temperature, cold welding point of KP and KN being 0°C. (Example at 1000°C, EMF of a couple is 41.269 mV).

To calculate the EMF of a couple to be matched, algebraic sum of the deviations values indicated on the labels with the material must be added to the standard value indicated on the table below, for a given temperature. The result is the exact EMF value of the couple at this temperature.

Example:
KP at 1000°C deviation + 0,04
KN at 1000°C deviation - 0,06
EMF of couple at 1000°C:
41,269 +0,04 - (-0,06) = 41,369 mV

5. Couple KP/KN EMF reference table (mV)

°C	0	10	20	30	40	50	60	70	80	90	100
0	0	0.397	0.798	1.203	1.611	2.022	2.436	2.85	3.266	3.681	4.095
100	4.095	4.508	4.919	5.327	5.733	6.137	6.539	6.939	7.338	7.737	8.137
200	8.137	8.537	8.938	0.341	9.745	10.151	10.56	10.969	11.381	11.793	12.207
300	12.207	12.623	13.039	13.456	13.874	14.292	14.712	15.132	15.552	15.974	16.395
400	16.395	16.818	17.241	17.664	18.088	18.513	18.938	19.363	19.788	20.214	20.64
500	20.64	21.066	21.493	21.919	22.346	22.772	23.198	23.624	24.05	24.476	24.902
600	24.902	25.327	25.751	26.176	26.599	27.022	27.445	27.867	28.288	28.709	29.128
700	29.128	29.547	29.965	30.383	30.799	31.214	31.629	32.042	32.455	32.866	33.277
800	33.277	33.686	34.095	34.502	34.909	35.314	35.718	36.121	36.524	36.925	37.325
900	37.325	37.724	38.122	38.519	38.915	39.31	39.703	40.096	40.488	40.879	41.269
1000	41.269	41.657	42.045	42.432	42.817	43.202	43.585	43.968	44.349	44.729	45.108
1100	45.108	45.486	45.863	46.238	46.612	46.985	47.356	47.726	48.095	48.462	48.828

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6. Conversion tables

KP wire

B&S or AWG					SWG					Metric			
B&S or AWG	Dia mm	Ohm/m	Length m / kg	Weight g / m	SWG	Dia mm	Ohm/m	Length m / kg	Weight g / m	Diameter mm	Ohm/m	Length m / kg	Weight g / m
8	3.251	0.085	13.8	72.4	10	3.251	0.085	13.8	72.4	4	0.0561	9.12	72.3
10	2.591	0.133	21.7	45.9	13	2.337	0.164	26.7	37.4	3.26	0.085	13.8	72.3
11	2.311	0.168	27.3	36.5	14	2.032	0.817	35.3	28.3	3	0.0998	16.2	61.6
12	2.057	0.212	24.5	28.9	15	1.829	0.269	43.6	22.9	2.5	0.144	23.3	42.8
13	1.829	0.269	43.6	22.9	16	1.626	0.34	55.2	18.1	2.05	0.213	34.7	28.8
14	1.626	0.34	55.2	18.1	18	1.219	0.605	98.2	10.2	1.8	0.277	45.1	22.2
16	1.295	0.536	87	11.5	19	1.016	0.871	141.4	7.07	1.63	0.338	54.9	18.2
20	0.813	1.359	220.9	4.52	21	0.813	1.359	220.9	4.52	1.29	0.54	87.7	11.4
24	0.311	3.442	559.1	1.78	25	0.508	3.483	565.8	1.77	0.81	1.37	222.5	4.49
28	0.32	8.778	1426	0.7	30	0.315	9.059	1471	0.679	0.5	3.595	584	1.71
32	0.203	21.81	35430	0.282	35	0.213	19.8	3218	0.311	0.3	9.987	1622	0.62
					38	0.152	38.9	6320	0.158	0.2	22.47	3650	0.27

KN wire

B&S or AWG					SWG					Metric			
B&S or AWG	Dia mm	Ohm/m	Length m / kg	Weight g / m	SWG	Dia mm	Ohm/m	Length m / kg	Weight g / m	Diameter mm	Ohm/m	Length m / kg	Weight g / m
8	3.251	0.0351	14	71.4	10	3.251	0.0351	14	71.4	4	0.0232	9.25	108
10	2.591	0.0554	22	45.3	13	2.337	0.068	27.1	36.9	3.26	0.0351	14	71.4
11	2.311	0.0696	27.7	36.1	14	2.032	0.09	35.8	27.9	3	0.0413	16.4	60.8
12	2.057	0.0878	35	28.6	15	1.829	0.111	44.2	22.6	2.5	0.0595	23.7	42.2
13	1.829	0.111	44.2	22.6	16	1.626	0.14	56	17.8	2.05	0.0884	35.2	28.4
14	1.626	0.14	56	17.8	18	1.219	0.25	99.63	10	1.8	0.115	45.7	21.9
16	1.295	0.221	88.3	11.3	19	1.016	0.36	143.4	6.97	1.63	0.14	55.7	17.9
20	0.813	0.562	224	4.46	21	0.813	0.562	224	4.46	1.29	0.223	88.9	11.2
24	0.311	1.423	567	1.76	25	0.508	1.44	573.7	1.74	0.81	0.566	225.6	4.43
28	0.32	3.63	1446	0.691	30	0.315	3.747	1492	0.67	0.5	1.487	592	1.69
32	0.203	9.021	3592	0.278	35	0.213	8.195	3263	0.306	0.3	4.131	1645	0.6
					38	0.152	16.09	6408	0.156	0.2	9.294	3701	0.27

Any intermediate diameter non above listed can be supplied upon request.

7. Recommendations for use

Our type K thermocouple competitive advantages

The type K thermocouple alloy manufactured by our company is melted with copper-nickel-silicon content instead of aluminium. One interesting advantage of this thermocouple is its very high stability in use at high temperature. On special request, we can supply a non aging material.

Environmental limitations

Type K has a better resistance to oxidation than other types of thermocouple (except type N) and is particularly recommended for oxidizing or inert atmospheres (see table of behaviours in part I). It should not be used without protection in sulphurous atmospheres, in reducing atmospheres or a long time in a vacuum.

Embrittlement of the wire can be generated, which would change the metallurgical structure of the thermocouple, or spoil quality of the EMF couple by attacking the chromium. In reducing atmospheres, KP develops green oxide, also known as "green rot", which decreases the chromium content. This phenomenon damages the metallurgical structure, resulting in reduction in EMF output. In addition, KP becomes magnetic due to lower chromium content. Pre-oxidized surface can be delivered in order to increase resistance to corrosion.

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