Temperature Controls Pty Ltd

Quality System
Quality Endorsed Company

ISO 9001:2008
Lic: 14412
SAI GLOBAL

7 YAMMA STREET SEFTON, NSW 2162 AUSTRALIA

Phone: 61 2 9721 8644 Fax: 61 2 9738 9339
Web: www.temperature.com.au Email: sales@temperature.com.au ACN: 650 190 183 ABN: 966 501 901 83

THERMOCOUPLES * RTD SENSORS * THERMOWELLS * EXTENSION CABLES * LEVEL SWITCHES

OPERATING MAINTENANCE INSTRUCTIONS

Thermocouples are the most widely used temperature sensors. They are low cost, interchangeable, robust and can measure a wide range of temperatures.

Thermocouples basically consist of two dissimilar metals/alloys that when junctioned, that will generate a small EMF signal if there is a temperature difference between the hot junction, (measuring junction) and the cold junction or the (reference junction).
The EMF signal will be dependent only on the temperature difference and as such a thermocouple cannot be tested properly while both junctions are at the same temperature unless you use a thermocouple indicator.

Although almost any two types of metal can be used to make a thermocouple, a number of standard types are used because they possess predictable output voltages and large temperature gradients.
It is essential for the wiring from the thermocouple (cold junction) to the measuring instrument be in compensating or extension grade material of the same calibration as the thermocouple. Using copper wires or other materials will cause loss of EMF and errors.

The law of intermediate metals states that a third metal, inserted between the two dissimilar metals of a thermocouple junction will have no effect provided that the two junctions are at the same temperature. This law is also important in the construction of thermocouple junctions. It is acceptable to make a thermocouple junction by soldering the two metals together as the solder will not affect the reading. In practice, thermocouple junctions are made by welding the two metals together; this ensures that the performance is not limited by the melting point of solder.
Thermocouples are available either as bare wire 'bead' thermocouples which offer low cost and fast response times, built into probes or mineral insulated metal sheath (MIMS) sensors.
A wide variety of probes are available, suitable for different measuring applications (industrial, scientific, food temperature, medical research etc).

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When choosing a thermocouple consideration should be given to both the thermocouple type, insulation and probe construction. All of these will have an effect on the measurable temperature range, accuracy and reliability of the readings.

Type K (Chromel / Alumel)

Type K is the 'general purpose' thermocouple. It is low cost and, owing to its popularity, it is available in a wide variety of probes. Thermocouples are available in the -200°C to +1200°C range. Sensitivity is approx 41uV/°C. Use type K unless you have a good reason not to.

Type “K” EMF in mV Ansi MC96.1 1975 IEC 584-3
(Reference Junction 0°C)

Material + Chromel / - Alumel
Colour + Yellow / - Red

°C	0	10	20	30	40	50	60	70	80	90	100
0	0.000	0.397	0.798	1.203	1.611	2.022	2.436	2.850	3.266	3.681	4.095
100	4.095	4.508	4.919	5.327	5.733	6.137	6.539	9.639	7.338	7.737	8.137
200	8.137	8.537	8.938	9.341	9.745	10.151	10.560	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	19.300	19.788	20.214	20.640
500	20.640	21.066	21.493	21.919	22.346	22.772	23.198	23.624	24.050	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	39.310	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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Type J (Iron / Constantan)

Limited range (-40 to +750°C) makes type J less popular than type K. The main application is with old equipment that cannot accept 'modern' thermocouples. J types should not be used above 760°C as an abrupt magnetic transformation will cause permanent decalibration.

Type “J” EMF in mV MC96.1 1975 IEC 584-3 (Reference Junction 0°C)
Material + Iron / - Constantan
Colour White / Red

°C	0	10	20	30	40	50	60	70	80	90	100
0	0.000	0.507	1.019	1.536	2.058	2.585	3.115	3.649	4.186	4.725	5.268
100	5.268	5.812	6.359	6.907	7.457	8.008	8.560	9.113	9.667	10.222	10.777
200	10.777	11.332	11.887	12.442	12.998	13.553	14.108	14.663	15.217	15.771	16.325
300	16.325	16.879	17.432	17.984	18.537	19.089	19.640	20.192	20.743	21.295	21.846
400	21.846	22.397	22.949	23.501	24.054	24.607	25.161	25.716	26.272	26.829	27.388
500	27.388	27.949	28.511	29.075	29.642	30.210	30.782	31.356	31.933	32.513	33.096
600	33.096	33.683	34.273	34.867	35.464	36.066	36.671	37.280	37.893	38.510	39.130
700	39.130	39.754	40.382	41.013	41.647	42.283	42.922	43.563	44.207	44.852	45.498
800	45.498	46.144	46.790	47.434	48.076	48.716	49.354	49.989	50.620	51.249	51.875

Type N (Nicrosil / Nisil)

High stability and resistance to high temperature oxidation makes type N suitable for high temperature measurements without the cost of platinum (B,R,S) types. Designed to be an 'improved' type K, it is becoming more popular.

Type “N” EMF in mV Ansi MC96.1 1975 IEC 584-3 (Reference Junction 0°C)
Material + Nicrosil/-Nisil
Colour + Orange / - Red

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°C	0	10	20	30	40	50	60	70	80	90	100
0	0.000	0.261	0.525	0.793	1.064	1.340	1.619	1.902	2.188	2.479	2.774
100	2.774	3.072	3.374	3.679	3.988	4.301	4.617	4.936	5.258	5.584	5.912
200	5.912	6.243	6.577	6.914	7.254	7.596	7.940	8.287	8.636	8.987	9.340
300	9.340	9.695	10.053		10.773	11.135	11.499	11.865	12.233	12.602	12.972
400	12.972	13.344	13.717	14.092	14.467	14.844	15.222	15.601	15.981	16.362	16.744
500	16.744	17.127	17.511	17.869	18.282	18.668	19.055	19.443	19.8.1	20.220	20.609
600	20.609	20.999	21.390	21.781	22.172	22.564	22.956	23.348	23.740	24.133	24.526
700	24.526	24.919	25.312	25.705	26.098	26.491	26.885	27.278	27.671	28.063	28.456
800	28.456	28.849	29.241	29.633	30.025	30.417	30.808	31.199	31.590	31.980	32.370
900	32.370	32.760	33.149	33.538	33.927	34.315	34.702	35.089	35.476	35.862	36.248
1000	36.248	36.633	37.018	37.403	37.786	38.169	38.552	38.934	39.316	39.696	40.076
1100	40.076	40.456	40.835	41.213	41.590	41.966	42.342	42.717	43.091	43.464	43.836
1200	43.836	44.207	44.578	44.947	45.315	45.682	46.048	46.413	46.777	47.140	47.502
1200	47.502										

Thermocouple types B, R and S are all 'noble' metal thermocouples and exhibit similar characteristics. They are the most stable of all thermocouples, but due to their low sensitivity (approx 10uV/^{0}C) they are usually only used for high temperature measurement (>600°C). These Noble metal thermocouples all require high purity ceramic protection sheaths for use in industrial applications.

Type B (Platinum / Rhodium)

Suited for high temperature measurements up to 1800°C.

Type R (Platinum / Rhodium)

Suited for high temperature measurements up to 1600°C. Low sensitivity (10uV/°C) and high cost.

Type S (Platinum / Rhodium)

Suited for high temperature measurements up to 1600°C. Due to its high stability type S is used as the standard of calibration for the melting point of gold (1064.43°C).

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Precautions and Considerations for Using Thermocouples

Most measurement problems and errors with thermocouples are due to a lack of understanding of how thermocouples work. Thermocouples can suffer from ageing and accuracy may vary consequently especially after prolonged exposure to temperatures at the extremities of their useful operating range. Listed below are some of the more common problems to be aware of.

Connection problems

Many measurement errors are caused by unintentional thermocouple junctions. Any junction of two different metals will cause a junction. If you need to increase the length of the leads from your thermocouple, you must use the correct type of thermocouple extension wire (eg type K for type K thermocouples). Using any other type of wire will introduce a thermocouple junction. Any connectors used must be made of the correct thermocouple material and correct polarity must be observed. Any shorting of the thermocouple leads in the terminal head or connector will create another junction and the instrument will read this temperature not the hot junction temperature.

Lead Resistance

To improve response times, thermocouples are made of thin wire (in the case of platinum types cost is also a consideration). This can cause the thermocouple to have a high resistance which can make it sensitive to noise and can also cause errors due to the input impedance of the measuring instrument. A typical exposed junction thermocouple with 32AWG wire (0.25mm diameter) will have a resistance of about 15 ohms / meter. If thermocouples with thin leads or long cables are needed, it is worth keeping the thermocouple leads short and then using thermocouple extension wire (which is much thicker, so has a lower resistance) to run between the thermocouple and measuring instrument.

Noise

The output from a thermocouple is a small signal, so it is prone to electrical noise pick up. If operating in an extremely noisy environment, (such as near a large electric motor) it is

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recommended using a screened extension cable. If noise pickup is suspected first switch off all suspect equipment and see if the reading changes.

There are no maintenance functions possible on a thermocouple, however scheduled calibration checks are recommended.
Thermocouples do drift in calibration, but rate of drift is dependent upon time and temperature. In a known temperature source check the thermocouple output against the Thermocouple Degrees C vs. EMF Tables.

Thermocouples or their wiring can go short circuit or open circuit causing error signals. Another fault condition for Data loggers or Transmitters is poor insulation resistance between the conductors and earth resulting in a grounding of the thermocouple loop.

If the thermocouple shows either of the 3 fault conditions it should be replac