Temperature °Controls Pty Ltd

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REF: 1117 Thermocouple – Rev 02 27/04/20

OPERATING MAINTENANCE INSTRUCTION

General

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

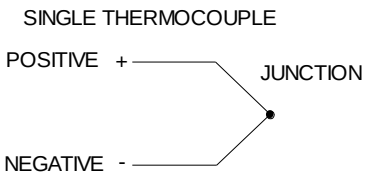
Thermocouples consist of two dissimilar metals/alloys that when will generate a small EMF signal when junctioned and exposed to a temperature gradient between the hot junction and measuring point (cold/reference junction). The EMF signal is dependent on the temperature difference and as such, a thermocouple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

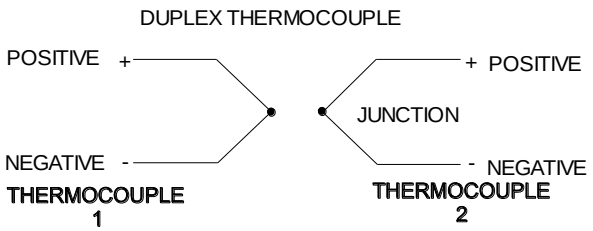
Although almost any two types of metal can be used to make a thermocouple, a number of standard types are used as they possess predictable and repeatable output voltages and large temperature gradients. Given this fact, it is essential for the wiring from the thermocouple (cold junction) to the measuring 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). 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.

Connection Detail





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Type K (Chromel / Alumel)
Type K is the 'general purpose' thermocouple. It is low cost and, owing to its popularity, is available in a wide variety of assembly styles. Thermocouples are available in the -200°C to 1200°C range. Sensitivity is approx. 41µV/°C. It is recommended to consider a type K thermocouple unless there is good reason not to.

Type K EMF in mV according to ANSI MC96.1 1975 IEC 584-3
(reference junction 0°C)

Material: Chromel (pos) / Alumel (neg)
Colour: Yellow (pos) / Red (neg)

°C	0	10	20	30	40	50	60	70	80	90
0	0.000	0.397	0.798	1.203	1.611	2.022	2.436	2.850	3.266	3.681
100	4.095	4.508	4.919	5.327	5.733	6.137	6.539	9.639	7.338	7.737
200	8.137	8.537	8.938	9.341	9.745	10.151	10.560	10.969	11.381	11.793
300	12.207	12.623	13.039	13.456	13.874	14.292	14.712	15.132	15.552	15.974
400	16.395	16.818	17.241	17.664	18.088	18.513	18.938	19.300	19.788	20.214
500	20.640	21.066	21.493	21.919	22.346	22.772	23.198	23.624	24.050	24.476
600	24.902	25.327	25.751	26.176	26.599	27.022	27.445	27.867	28.288	28.709
700	29.128	29.547	29.965	30.383	30.799	31.214	31.629	32.042	32.455	32.866
800	33.277	33.686	34.095	34.502	34.909	35.314	35.718	36.121	36.524	36.925
900	37.325	37.724	38.122	38.519	38.915	39.310	39.703	40.096	40.488	40.879
1000	41.269	41.657	42.045	42.432	42.817	43.202	43.585	43.968	44.349	44.729
1100	45.108	45.486	45.863	46.238	46.612	46.985	47.356	47.726	48.095	48.462

Precautions and Considerations
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.

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

Maintenance
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 replaced.

Bending
MIMS thermocouples (Mineral Insulated Metal Sheath) may be bent at a radius of 5 times the sheath diameter without damage or reducing the effective insulation resistance between the conductors and sheath. A 3mmØ MIMS thermocouple for example can therefore be bent at 3mmØ x 5 = 15mm radius.

Insulation Resistance
MIMS thermocouples are generally supplied with insulated junctions. The thermocouples should have an insulation resistance of 100 megohms between conductor and sheath.

Recommended test voltages for insulation resistance test.

1.0mmØ	250VDC
1.5mmØ	250VDC
3.0mmØ	500VDC
4.5mmØ	500VDC
6mmØ and above	1000VDC