Temperature °Controls Pty Ltd

ACN: 075 298 592 ABN: 966 501 901 83

Sydney (Head Office): 7 Yamma St, Sefton, NSW 2162 Australia **Ph:** 61 2 9721 8644 **Fax:** 61 2 9738 9339
Melbourne: 8/280 Whitehall St, Yarraville VIC 3013 Australia **Ph:** 61 3 9687 0000 **Fax:** 61 3 9687 1900
Brisbane: 36, 121 – 125 Kerry Rd, Archerfield, QLD 4108 Australia **Ph:** 61 7 3373 8424 **Fax:** 61 7 3373 8067
W: www.temperature.com.au **E**: sales@temperature.com.au

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.

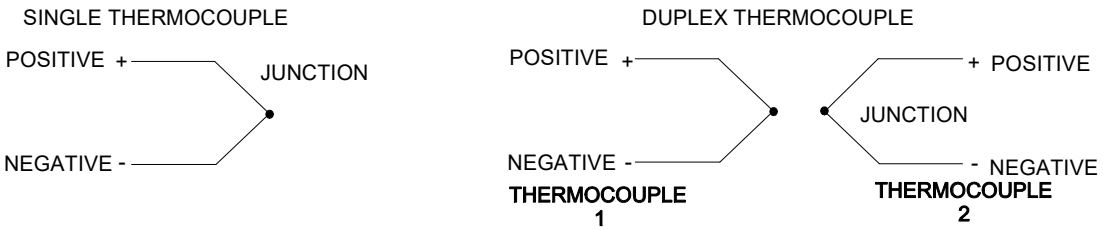
Thermocouples consist of two dissimilar metals/alloys that when will generate a small EMF signal when junctioned and exposed to a temperature gradient between the hot junction and measuring point (cold/reference junction). The EMF signal is dependent on the temperature difference and as such, a thermocouple 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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Certified System Quality ISO 9001 SAI GLOBAL LIC 14412

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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

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