ADVANCED INDUSTRIAL SYSTEMS, INC.

Applications Note 503

Thermocouple Tips and Techniques

Thermocouples are relatively simple devices, but have lots of idiosyncrasy. For many of you this will be excessively simplified, but for others I hope that the simplicity aids in understanding. Of course, we always welcome comments at David@AdvIndSys.com.

There are basically five considerations in Thermocouple Land:

1) Red is always (–). When using TC's like colors must be connected and Red is always negative.
2) TC's must be run with TC wire all of the way back to the "cold junction". The TC wire must be of the same type as the TC. The most common types of TC's are J, K, and T. Type J wire is sometimes mixed-up with regular copper red and white wire. If in doubt you can check it with a magnet. The iron (white) wire is highly magnetic. Copper wire in not. See below for a table of colors.
3) TC's measure the difference in temperature between the "Hot Junction" and the "Cold Junction". The process end is called the "Hot Junction" and the instrumentation end is called the "Cold Junction".
4) TC's are available in 4 grades, Extension wire (good to about 200°C), Standard Grade TC wire, Special Limits, and Ultra or Triple limits (Generally only available in Type T).
5) TC's are available as grounded and ungrounded junctions.

Now for some details:

1) Red is always (-) in thermocouple land (unlike the rest of the world which considers red (+)). All TC types are color coded. For the most popular types (J, K, and T) the color codes are shown below. A.I.S. also carries other TC types for special applications.

ANSI Code	Alloys	Single Conductor Color	Thermocouple Grade Jacket Color	Extension Grade Jacket Color	Magnetic?
J	+ Iron				Y
	- Constantan				
K	+ Nickel/Chromium				
	- Nickel/Aluminum				Y
T	+ Copper				
	- Constantan				

2) It is important to make sure that the entire run is of the same type of thermocouple material. Shielded extension wire is preferred. TC's have very small outputs (about 30 mV full scale), so it is important to avoid as much noise as possible. For extremely long runs, TC transmitters have become more and more economical. TC transmitters measure and linearize the TC, sending 4 – 20 mA down regular copper wire. Linearizing TC transmitters are available for about $ 150.00. Distributed Data Acquisition modules also lessen the need for long runs of TC wire. There prices have also decreased dramatically to under $ 500.00 for 8 inputs.

   Care should be taken that the loop resistance of the TC remains low. I generally consider TC loop resistance of less than 350 Ω to be desirable.

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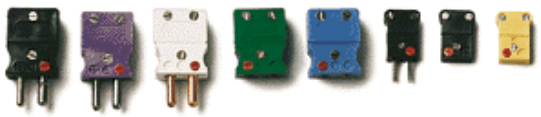
3) TC's measure the difference in temperature between the "Hot Junction" and the "Cold Junction". The process end is called the "Hot Junction" and the instrumentation end is called the "Cold Junction". (Even when the process junction is coldest, it is still called the "Hot Junction".) In the measuring instrument, the transition temperature is measured and used to compensate the reading so that actual temperature is displayed. You will often see this referred to as CJC or "Cold Junction Compensation". In critical applications, the TC to Cu transition point is often insulated. This insures that the transition point is measured accurately. CJC is often the greatest source of errors in near room temperature measurements.



TC connectors may be used in the TC line, but make sure the connector matches the TC type, In screw terminal applications, links of TC material are available. Of course make sure that the red wire is connected to the (-) terminal. Mis-wired TC connectors, and mis-wired extension wire are a frequent source of error in TC applications. If you wire the TC backwards, the indicated temperature will go down instead of up. If you miswire the connectors, the temperature may read about right, but have an error of about 10° or more.

4) TC's are available in 4 grades. I have used type T as an example in the text below. If you use J, K, or some other TC, substitute that letter for the T (i.e. JX, KX, etc.) Remember that near room temperature, the major source of error is the Cold Junction Compensation.

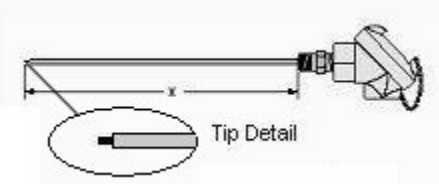
TX - Extension wire (good to about 200°C), TC extension wire is less expensive than regular TC wire. It is most desirable when shielded. TC extension wire is generally used near room temperature.

T - Standard Grade TC wire Used for most normal industrial applications

TT - Special Limits, used for laboratory and regulatory applications. Often required by organizations such as ASHRE, ASME, etc for measurements which affect certification.

TTT - Ultra or Triple limits (Generally only available in Type T). These types are often required for extremely tight calibration and measurement such as FDA certifications. Triple limits wire is available from a very small number of suppliers. A.I.S. carries triple limits wire in stock.

5) TC's are available as grounded and ungrounded junctions. In the olden days, this was a bigger issue. Most modern instrumentation will accept either without a problem. Older equipment without isolated inputs sometimes had problems with grounded TC's. Of course single ended inputs still have problems with grounded TC's. Erratic readings are the most common problem. Grounded TC's do have faster response time, as there is less thermal insulation between the heat source and the junction. If you really need the faster response time, we recommend a reduced diameter tip (see picture). This gives you the best of both worlds for most applications. See our web site for additional examples of TC's… http://www.advindsys.com/TC.htm .



There is a lot more to say. This is only a brief introduction. I have tried to maintain a non-technical approach on purpose. Feel free to call or e-mail us for additional information. For our entire set of Applications notes please visit us at: www.AdvIndSys.com/ApplicationsNotes.htm .

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