ISOTECH

Whitepaper

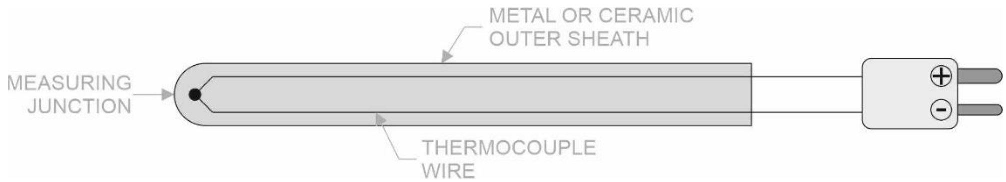
The accuracy of the CJC sensor in a temperature indicator is critical in order to make accurate measurements with thermocouples

The use of a DJT provides a test thermocouple with a RJ which is inherently more accurate than using an electronic internal CJC system

PART 1: Double Junction Thermocouple
What is it and how can it be used?

The Thermocouple

In simple terms a thermocouple is made up of two wires of different metals welded together to form a measuring junction, the wires are insulated with PTFE, ceramic or compressed mineral (MIMS) and the wires are terminated in a plug whose connectors are manufactured from the same material as the wire.



Note: A thermocouple only generates an output when a temperature gradient exists across the length of the wire.

Thermocouple are invariably used with some form of temperature indicator.

Cold Junction Compensation (CJC)

As the thermocouple above is connected to a temperature indicator the wires of the thermocouple are connected to the copper input terminals of the temperature indicator. This connection is made at ambient temperature.

Considering the note above, the measurement at the input terminals will be as follows;

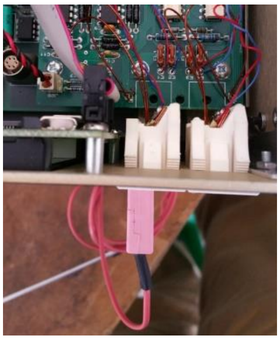
$t_m (= t_g) = t_p - t_a$

Where;
t_m = *Measured temperature*
t_g = *Temperature gradient along the thermocouple wires*
t_p = *Process temperature*
t_a = *Ambient temperature*

81 °C = 100 °C − 19 °C

As can be seen the measured temperature is in error by the equivalent of ambient temperature, therefore a correction or compensation needs to be made.

Temperature indicators do this using a temperature sensor positioned in close physical and thermal proximity to its copper input terminals. This sensor is usually an RTD, thermistor or diode and is used to pick up the temperature of the input terminals.



CJC temperature sensor embedded into the rear of a thermocouple input connector of a temperature indicator

The electronics of the indicator then adds this Cold Junction Compensation (CJC) temperature value to the measured value on its inputs to provide compensation for this ambient error.

The measured temperature can now be described as;

$t_m (= t_g) = t_p - t_a + t_c$

Where;
t_m = *Measured temperature*
t_g = *Temperature gradient along the thermocouple wires*
t_p = *Process temperature*
t_a = *Ambient temperature*
t_c = *CJC temperature*

100 °C = 100°C – 19 °C + 19 °C

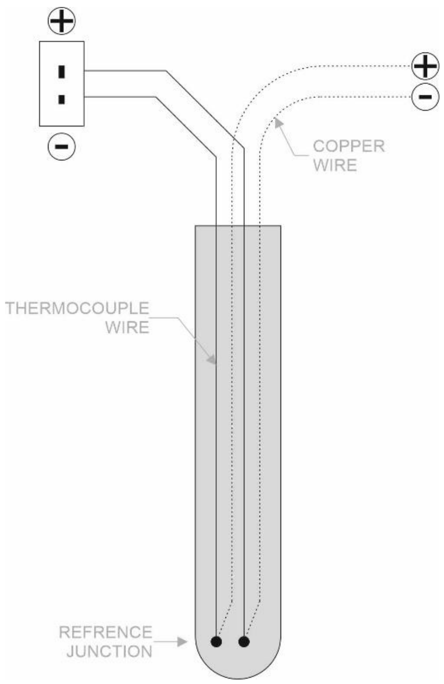
As can be appreciated the accuracy of this CJC sensor is critical in order to make accurate measurements with thermocouples (to be discussed in Part 2).

Cold Junction (CJ) or Reference Junction (RJ)

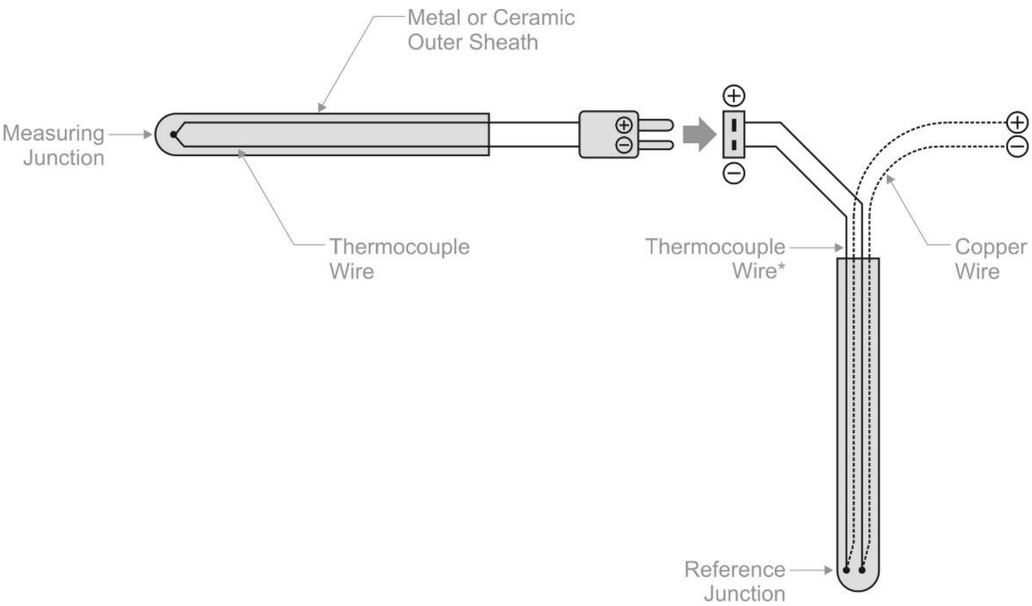
Where a user doesn't have access to a dedicated temperature indicator a measuring instrument such as a Digital Voltmeter (DVM) may be used. This type of instrument is unlikely to have the capability to provide internal CJC.

Under these circumstances the user will require additional equipment to measure the output of the thermocouple.

This is done by utilising a Double Junction Thermocouple (DJT).



The DJT consists of a length of thermocouple wire with copper wires welded to one end. This weld or junction is known as the Cold Junction (CJ) or Reference Junction (RJ), it will be referred to as RJ throughout this paper.



The open end of the DJT can be connected to the output of the test thermocouple via a suitable thermocouple plug/socket.

By maintaining the RJ at a known constant temperature (generally 0°C) the output of the thermocouple can be measured accurately via the copper wires connected to the DVM.

Isotech produce a Model 880 Double Junction Thermocouple which can be manufactured for any thermocouple type.

The measured temperature can now be described as;

$t_m = t_p + t_r$

Where;
t_m = *Measured temperature*
t_p = *Process temperature*
t_r = *RJ temperature*

100 °C = 100 °C + 0 °C

The method of using these DJT to provide the test thermocouple with a RJ is inherently more accurate than using an electronic internal CJC system.

However, to attain the ultimate accuracy, the errors associated with the DJT must be established and corrected for during use (to be discussed in Part 2).

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Calibration of a Double Junction Thermocouple (DJT)

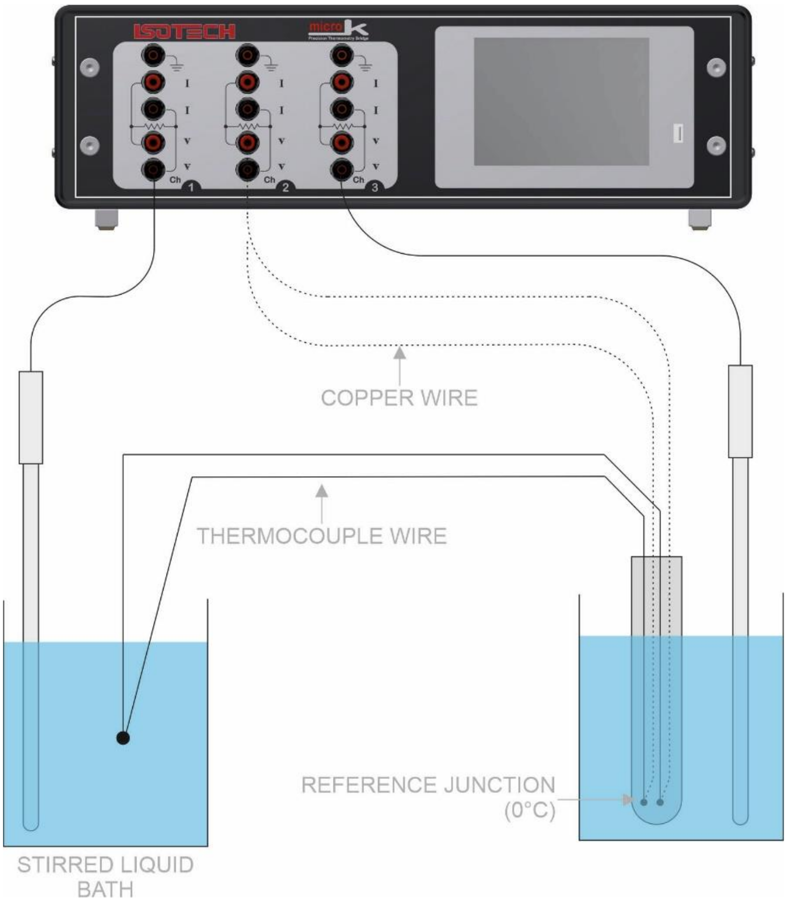
To establish the error associated with the DJT the thermocouple must be calibrated.

In order to do this the open end of the DJT must be welded together to create a measuring junction.

A typical calibration set up is shown below.

The measuring junction is placed into a stirred liquid bath and the RJ is placed into ice/water or in a TRU (thermocouple reference unit) or similar device.

Both baths should be stable and measured with calibrated thermometers. The output of the DJT is measured on a calibrated DVM. Alternatively, all three measurements could be accommodated simultaneously on a microK.



By converting the temperature of the stirred liquid bath to equivalent Voltage using IEC 60584-1 (for the specific thermocouple type being calibrated), this value can then be compared to the DJT output to establish its error.

As the DJT will only ever be connected to a test thermocouple at ambient temperature then the temperature of interest and hence the calibration points should span ambient, 15 °C to 25 °C.

Example Results:

Measured liquid bath temperature °C	Equivalent Type J Voltage (IEC 60584-1) µV	Reference junction temperature °C	Measured output of Type J DJT µV	Double junction error (DJT output - Equivalent IEC 60584-1) µV
15.00	762	0.00	763	+1
20.01	1020	0.00	1021	+1
24.99	1277	0.00	1278	+1

Once calibrated the error associated with the double junction thermocouple can be corrected for during use.

Help and Advice

If you need low uncertainty measuring systems we can help, contact us for free advice and consultation. We have proven solutions at all levels in temperature metrology, from high accuracy cost effective industrial measurements systems to the lowest uncertainty systems for primary metrology used by the world's leading National Metrology Institutes.

If you have any questions, if you need any advice, if you would like a free consultation then please get in touch