Following the previous introduction to thermocouples and Pt100s, we now continue with the thermocouple's construction and applications, and will do the same for the Pt100 in the next issue.

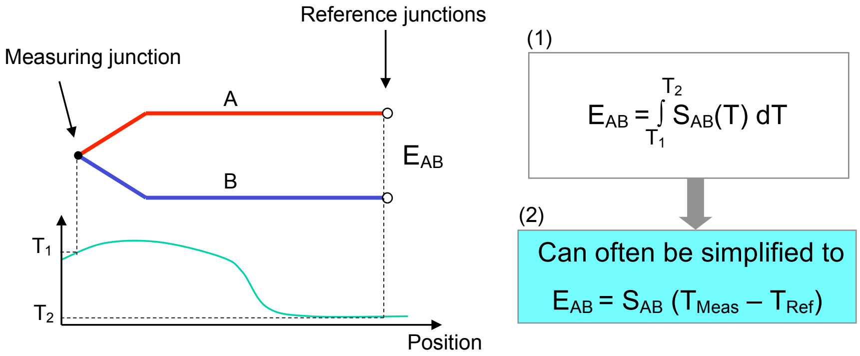
LESSON 6 THE THERMOCOUPLE – ITS CONSTRUCTION AND APPLICATIONS

THE THERMOCOUPLE MEASURES TEMPERATURE DIFFERENCES

A fundamental feature of the thermocouple is that two known and different materials are kept insulated from each other except at the precise point where the temperature is to be measured. Along the thermocouple a thermoelectric effect occurs, which generates a measurable voltage. It is very important that there is good insulation between the materials; moisture or mechanical effects can cause large measurement errors because the insulation deteriorates. In a normal sheathed thermocouple, magnesium oxide is often used as insulation.

The thermocouple measures the temperature difference between the measuring junction and the reference junction. See the figure. Correct temperature measurement requires that the sensitivity, or the Seebeck coefficient (SAB which is measured in e.g. μV/ °C), is the same along the length of the thermocouple wires. We usually say that the thermocouple must be homogenous.

To be able to measure the Seebeck voltage without error, the circuit must have no electrical load. Using digital voltmeters, you would normally load the measuring circuit with such a low current that the measurement error becomes insignificant. When an electrical load is present, the signal output will be more complex because factors such as Ohm's law affect the result.



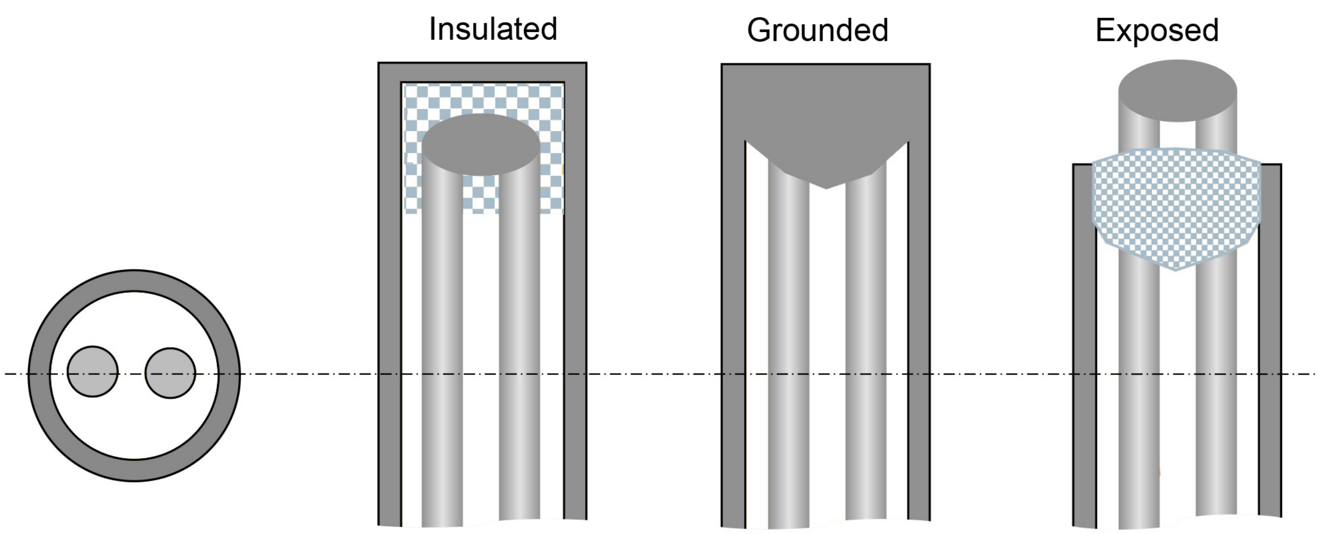
The figure shows at left a thermocouple that is exposed to a temperature gradient. The signal output EAB is generally expressed by an integral, but can often be simplified to the sensitivity (the Seebeck coefficient multiplied by the temperature difference between the measuring and reference junctions).

MEASURING JUNCTION CONSTRUCTIONS

For sheathed thermocouples there are usually three different types of measuring junction construction: insulated, grounded and exposed, as shown in the figure below. For sheathed thermocouples the measuring junction is easy to form and can be insulated from the sheath.

The insulated measuring junction is the most common type and is a sturdy construction in which the measuring junction is well protected from external influence. The heat transfer must occur through the sheath material and the insulation, which makes this construction somewhat slower than the others. However, on the other hand, the measuring junction is protected and independent of the sheath material's movement due to temperature differences.

Measuring junctions that are welded in contact with the sheath –



Sheathed thermocouples with the measuring junction's locations shown in cross-section. The diameter of the wires is normally approx. 20% of the sheath's outer diameter. The sheath's thickness is normally approx. 10-15% of the outer diameter.

grounded measuring junctions – are sometimes used when faster temperature responses are desired. However, grounded measuring junctions have weaknesses. When a measuring junction is fused with the outer sheath, a larger number of substances are fused together compared with when only the wires are fused together. This, combined with the fact that the thermocouple is exposed to rapid and large temperature changes, can cause the measuring junction to break.

An exposed measuring junction is only used in exceptional cases when the temperature range is limited and extremely short response times are required. The measuring junction is unprotected and the sealing material at the tip can easily crack, which often causes moisture problems.

EIGHT STANDARDISED THERMOCOUPLE TYPES

The IEC* has standardised eight thermocouple types from the great variety of thermocouples that are used in the world. Of the eight, E, J, K, N and T consist of base metal alloys whilst S, R and B contain the noble metal platinum.

Of the base metal ones, type K and increasingly type N are currently the most commonly used thermocouples. Type J is only used in exceptional cases in new constructions, as is type T.

Type T is often used for physiological measurements based on its advantages at those temperatures; an even more stable temperature sensor is RTD (Pt100).

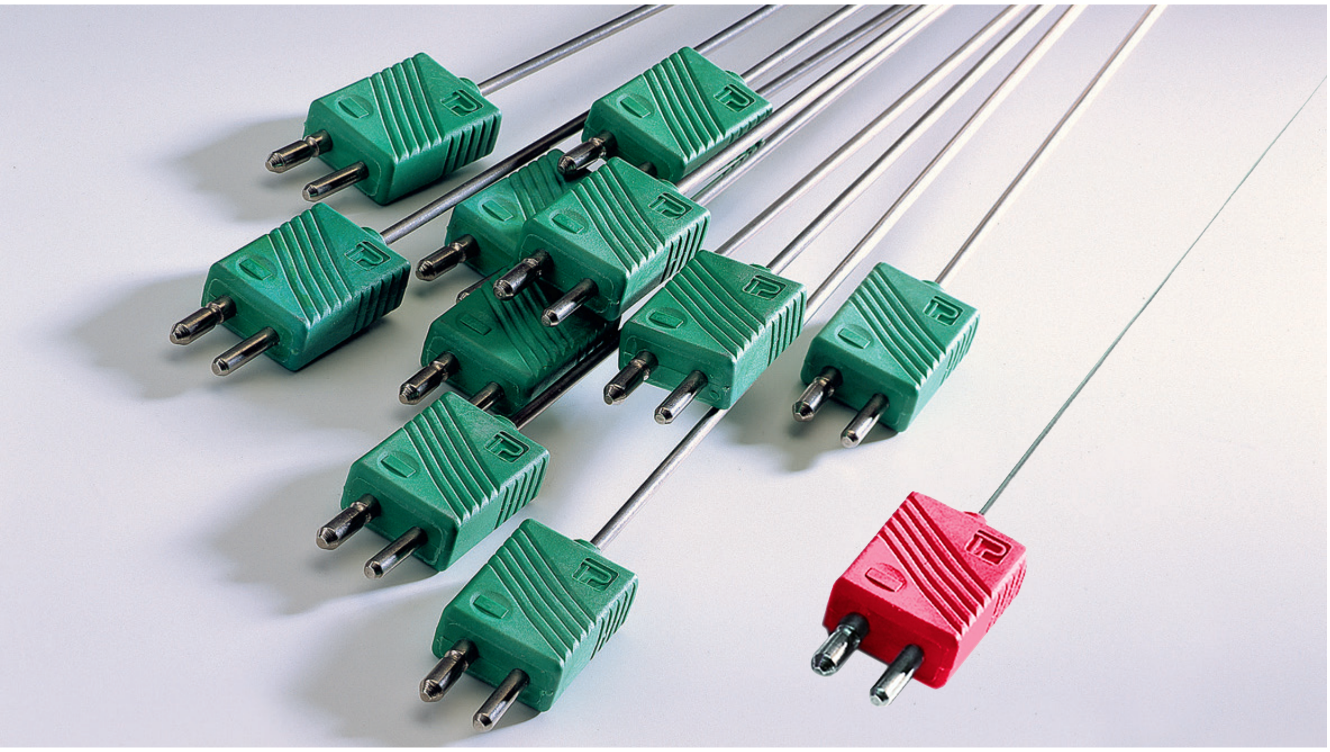
The above concepts are deliberately vague because few users have exactly the same conditions in their respective processes. At higher temperatures, the ambient environment plays a greater role for the thermocouple's operating time within the stated specification.

**International Electrotechnical Commission.*

Type	IEC colour	Working range in °C	Atmosphere
E	(violet)	-200 – 900	Good in oxidising atmospheres
J	(black)	-200 – 760	Not for oxidising environments or acids
K	(green)	-200 – 1200	Good in oxidising atmospheres
N	(pink)	0 – 1300	Like K but normally better above 200 °C
T	(brown)	-200 – 370	Non-oxidising atmospheres
S/R	(orange)	0 – 1480	Ceramic protection tubes in all atmospheres
B	(grey)	0 – 1700	Ceramic protection tubes in all atmospheres

This table shows the approximate working ranges. The environment, physical dimensions and sheath of the thermocouple affect its lifespan and temperature range.

If you would like to discover even more about temperature measurement, Pentronic offers courses in traceable temperature measurement in Västervik or at your own premises if required. For more information visit www.pentronic.se



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