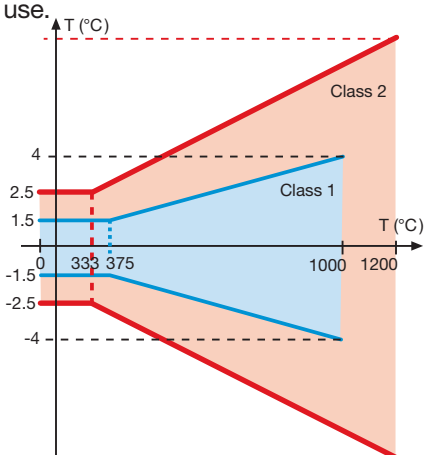
SHEATHED THERMOCOUPLES – PRACTICAL ADVICE AND PROBLEM SOLVING, PART 2

The first part of *Pentronic News'* series on sheathed thermocouples gave an overall introduction to this type of sensor along with various kinds of construction and use. Part 2 gives information about some important error sources which you should know about when using sheathed thermocouples. The focus is on type K thermocouples, which is the most common type of thermocouple.

The legs/conductors of type K thermocouples consist primarily of a nickel/chromium and a nickel/aluminium alloy respectively. The designations used include NiCR/NiAl. Thermocouples are standardised in accordance with IEC 60584-1:2013 and have the tolerance classes 1 and 2 (see figure). However, it is very important to keep in mind that the tolerance limits only guarantee a thermocouple's properties at the time of delivery. A thermocouple is affected by its surroundings and its use.

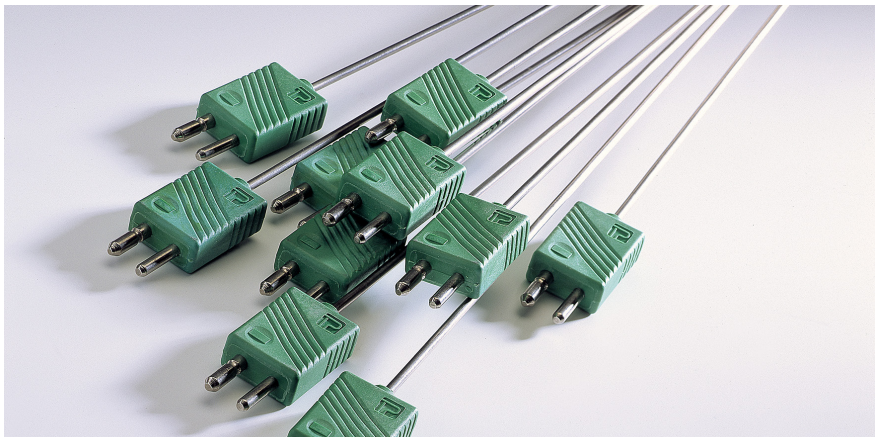


Tolerances for types K thermocouples in accordance with IEC 60584-1:2013. (°C) Class 1: the greater of 1.5 or 0.004 x t. Class 2: the greater of 2.5 or 0.0075 x t.

For that reason, we present here a description of common error sources which are important to consider in your risk analysis or error budget, in addition to the stated tolerance classes.

	Error source for thermocouple K	Deviation max temperature (°C) <200 °C	<600 °C	<1200 °C
1	Homogeneity	≤ 0.1	0.1-1	2-6
2	Ageing	≤ 0.1	< 2	1-50
3	Hysteresis	–	2-5	2-5
4	Green rot	–	–	10-100
5	Reference junction	0.3-3	0.3-3	0.3-3

Measurement errors that can affect type K thermocouples within various temperature ranges. The sizes of the errors are estimated relatively roughly but they can still act as guidelines for where to look for the biggest sources of error in an installation.



HOMOGENEITY

A thermocouple is not a single-point sensor. Instead, it measures the temperature differences that are accumulated along the sensor's entire length from the measuring junction to the reference junction. The longer a sensor is, the greater the requirements that the legs' alloy and properties are totally homogenous along the sensor's length. In demanding applications with long thermocouples, we recommend that you consult specialists to get the correctly selected and tested material for your sensors. Pentronic's experts can help you with the correct choice.

AGEING

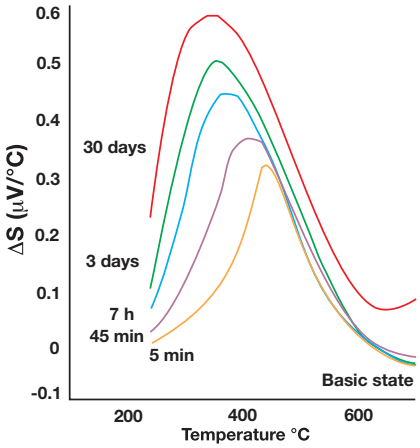
In general, thermocouples should be regarded as perishable goods, even though in the absolute majority of the applications, they can maintain fully sufficient accuracy for many years. However, you need to be aware that higher temperatures in particular accelerate the ageing process. Ageing involves a gradual alteration of the alloys' properties which worsens the accuracy over time. At high temperatures, especially above 1000 °C, the metal sheath can also no longer be regarded as a hermetic shield against contaminants, and the sensors age far faster.

SRO HYSTERESIS

SRO hysteresis is perhaps not a commonly known term, but Pentronic uses the expression to describe a phenomenon that primarily affects thermocouples of base metal alloys (e.g. type K). SRO stands for "Short Range Ordering" and refers to variations in the alloys' crystal structures. Type K thermocouples are affected by this phenomenon primarily during cycling within the temperature range of 200–600 °C. What happens is that when cycling occurs between high and low temperatures, the signal response from the sensor is different on the way up compared with on the way down in temperature. SRO hysteresis is an often unknown factor behind surprisingly large errors, mainly when calibrating. We recommend additional reading on this topic:

READ MORE:

Type N thermocouples give a smaller calibration error than type K.



Changes in the Seebeck coefficient for type K thermocouples as a function of temperature level and exposure time. The critical zone is 200-600 °C.

GREEN ROT

For type K thermocouples, there is a risk within the range of 800–1050 °C that the legs are affected by green rot. This term is used to describe an oxidisation process on the legs that produces a green-coloured chromium oxide. The reason why it is very important to know about this, is that it can be a major error source which is fairly unnecessary to risk. Oxidation at these temperatures depletes the alloy, which rapidly affects the measurement results. As mentioned before, it is important to keep in mind that using a sheathed thermocouple gives no significant benefit, because at these temperatures the sheath provides no appreciable protection. However, it is easy to solve this problem by using a type N thermocouple instead.

THE REFERENCE JUNCTION

A thermocouple always has a reference junction or “cool junction” as it is often called. This is placed as close as possible to where the thermocouple is connected (signal converter, logger or indicator). In order to be able to interpret signals from a thermocouple, regardless of type, the cool junction must have a known temperature. It is therefore always crucially important that during the installation process you know what specification your cool junction has in terms of accuracy, and that you regularly evaluate the point itself: can its accuracy over time have been affected due to its environment or handling?

INSTALLATION

Also remember to always analyse the installation of thermocouples as a part of your error budget. For example, measurement accuracy is easily affected if you use extension cables or if the cabling is drawn through different temperature ranges. For example, inside a furnace, where the temperature can be much higher close to the heaters at the edges of the furnace compared with the point where you have the material you want to measure.

Electromagnetic influences and insulation problems are also common error sources.

If you are planning for an application that has high requirements or if you are currently experiencing problems with your measurement processes, don’t hesitate to contact one of Pentronic’s experts for support!