

A thermocouple or a Pt100 sensor, which should I choose?

Briefly, we can say that thermocouples measure at higher temperatures and withstand mechanical strains such as vibrations better than Pt100 sensors, which have better accuracy within a limited temperature range but which can be sensitive to shock and vibration.

There are about a dozen types of thermocouple on the market: eight standardised ones and a few semi-standardised ones. The most common ones today are types K and N plus the noble metal types S/R and B. Platinum resistors are also available in various types of wire wound and thinfilm formats (Figure 3). In addition, there are Pt100 and Pt1000 sensors, the latter with ten times the resistance values of the Pt100. American standards require a slightly greater sensitivity in Pt100s than the international standard, IEC 60751, which is used in Europe, and this must be taken into account when combining a sensor with an indicator if they come from different sources.

Thermocouples measure the temperature difference, via the thermoelectric voltage, between the measuring junction and the reference junction [Ref 1]. Pt100/Pt1000 sensors measure the temperature, via the resistance, across their resistance loop [Ref 2].

Thermocouples are sturdy

At temperatures below 500–600 °C both thermocouples and Pt100 sensors can be used. See Figure 1. The choice between them will then be determined by the measurement environment and the required accuracy. Thermocouples can better withstand mechanical stresses such as vibrations, blows and shocks, whilst the more sensitive Pt100 sensors are significantly more accurate at low temperatures and are electrically very stable. Some wirewound Pt100 sensors drift less than 0.01 °C/year in favourable measurement environments. Small temperature changes and few temperature cyclings reduce drift.

At these temperatures, thermocouples permit a meaningful resolution of 0.1 °C whilst industrial Pt100 sensors normally perform to hundredths of a degree. In practice, the thermocouples will have shorter response times. For example a Pt100 sensor has more mass to heat or cool before the platinum loop reacts. [Ref 3]. A test in water (0.4 m/s) of equivalent sensor tips (ø 3 mm) showed that the Pt100 sensor required twice the

response time as the thermocouple (4 versus 2 seconds respectively).

The sensor's plasticity can also be decisive. Thermocouples in metal-sheathed cables are available down to 0.25 mm in diameter and can be shaped with the fingers up to approx. 3 mm in diameter. See Figure 2. Pt100 sensors can also be built into metal-sheathed cables, but only from 3 mm and more in diameter [Ref 4].

Pt100 more accurate

It is necessary to calibrate temperature sensors, and Pt100 sensors that have a well-defined and delimited measuring position in its platinum loop give a reliable calibration result, see Figure 3. In contrast, thermocouples measure temperature differences [Ref 1], which can lead to problems as the ageing processes at the tip and where the sensor is inserted through the wall of the vessel also tend to differ. This is usually an issue at higher temperatures, where Pt100 sensors cannot be used anyway, and where very high requirements for accuracy are impossible for other reasons.

Self heating

If you want to take measurements in materials such as insulation, air that is almost still, or other materials with a poor ability to conduct heat, an additional problem arises with Pt100 sensors. In order to measure the resistance of the platinum loop, a constant current within the range of 0.1 to 1 mA is usually applied. This current causes a not-insignificant heat power to develop in the detector that can raise the detector's temperature measurably over the real temperature. This phenomenon does not occur with thermocouples.

In order for thermocouples to function as intended, you must use cables of the same type all the way from the sensor to the measuring equipment. For Pt100 sensors the best results are achieved with a cable with four conductors leading to an indicator input designed for four connectors. Two- and three-conductor connections are more unreliable and require careful installation and handling to avoid measurement errors. However, using a Pt1000 sensor reduces the measurement errors from a two-conductor connection by a factor of ten. [Ref 4]

If you have questions or comments, contact Hans Wenegård: hans.wenegard@pentronic.se

Figure 1

	Property	TC	Pt
1	Low temperature < 600 °C	X	X
2	High temperature > 600 °C	X	
3	High accuracy		X
4	Stability over time		X
5	Unambiguous calibration		X
6	Robustness, vibration resistance	X	
7	Short response time	X	
8	Self heating		X
9	Measures absolute temperature		X
10	Measures temperature difference	X	

Figure 1. The table lists properties that primarily belong to thermocouples (TC) or Pt100 sensors (Pt) respectively.

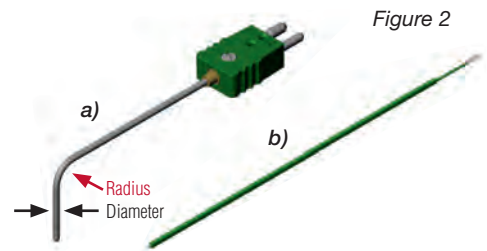


Figure 2. a) The radius of curvature must be greater than twice the sheath diameter. Example: A Ø 3 mm sheathing must be bent across round material of at least Ø 12 mm. Alternative: Use your fingers! b) The thermocouple wire is unprotected but has a very rapid response time.

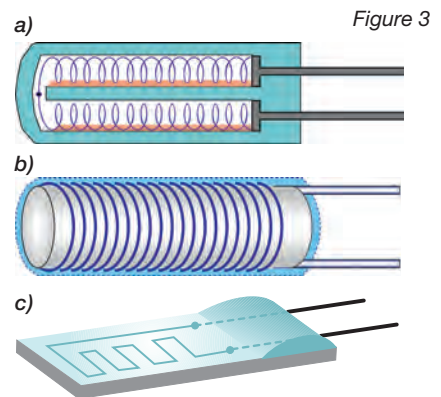


Figure 3. Various types of detectors a) wire-wound 80% free wire, b) bobbin-wound detector with fixed wire, c) thinfilm detector with a pattern cut into the platinum film. The dimensions of the thinfilm detector can be very small, e.g. 0.9 x 1.25 x 1.7 mm.

References see www.pentronic.se > Pentronic News > Archive

[Ref 1] Pentronic News 2011-2 p 4

[Ref 2] Pentronic News 2008-1 p 4

[Ref 3] Pentronic News 2010-2, -3 p 4

[Ref 4] Pentronic News 2009-2 p 4