

What affects a Pt100 sensor's precision?

The Pt100 (RTD) is known to be the most accurate type of industrial sensor. However, all types of Pt100 resistor are not equivalent. In this article we sort out the various possibilities and limitations.

The IEC 60751:2008 standard is the most recent one from the IEC to describe platinum thermometers. Unlike previous versions of the standard, this one is based on the actual conditions affecting resistors and complete ready-to-use sensors. The standard also takes into account whether the complete sensors contain wirewound or film resistors. See Figure 1. Pt100 and Pt1000 are normally the most common types in industrial uses but other ohm numbers than 100 and 1000 do occur at 0 °C. The tolerances in degrees C are the same but the resistance values differ relative to the basic resistances. [Ref 1]

Wirewound vs film resistors

Film resistors have limited measuring ranges compared with wirewound ones. See Figure 2. This is because film resistors are less tolerant of heat and cold than platinum-wire ones. If you exceed the limits of the measuring range, there is a large risk that the resistance-temperature relationship within the limits is altered to a wider tolerance class or that the resistor is actually destroyed.

The standard defines general tolerance classes (given in Figure 2). Nothing stops manufacturers from making resistors that meet the tolerances within larger or smaller temperature ranges. In such cases the IEC requires that the manufacturer and purchaser must be in agreement.

Hysteresis is another phenomenon that is affected by the sensor construction. The cause of hysteresis is the differing length expansions of the platinum wire or film and the surrounding resistor body. The more fixed the physical connection is, the more the platinum is stretched or compressed with the changes in temperature, and the more it therefore alters its basic resistance due to causes other than the temperature dependence of the electrical resistance. Wirewound resistors with

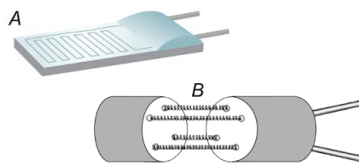


Figure 1. A) A film resistor. The "wire" is cut out from a thin sheet of platinum, which is fixed to a substrate. B) A wirewound resistor with 80% free wire, which minimises unintended resistance changes due to the differing expansion of the wire and the resistor body.

80% of the wire's length freely suspended are the best of the industrial versions.

Careful manufacture

The assembly of a resistor and its protection tube can cause additional measurement errors that alter the tolerance or its temperature interval. The risks depend on how the resistor is handled during manufacture. For example, finger grease must not come in contact with the resistor's body. At higher temperatures or lower pressures this can cause gases, which, if they penetrate the body, will contaminate the platinum wire and result in altered resistance. For the same reason, oil residues, which can occur in protection tubes, and heavy metals, must not come in contact with the platinum wire in the resistors.

Adhesives and gels, which are usually used for electrical isolation and vibration dampening inside the sensor, must also be carefully chosen with regard to the sensor's intended use. Otherwise measurement errors can already occur at temperatures from about 100 °C. The reason is that these materials' electrical isolation ability decreases with increasing temperature.

Calibration

Calibration is necessary in order to give the sensor readings traceability to the ITS-90 temperature scale. The most reliable way to establish traceability is a correction term with measurement uncertainty statements. [Ref 2]. An accredited calibration laboratory for temperature can perform

such a calibration. Pt100 sensors are normally so stable that calibration at a few points is enough to establish traceability between the points as well. See Figure 3.

Pentronic's accredited laboratory performs calibration by comparison on Pt100 sensors within -80 to 200 °C with a measurement uncertainty of ± 0.015 °C, and within 200 to 550 °C with a measurement uncertainty of ± 0.02 °C. For this to be done, the method's required conditions, such as the minimum insertion depth, must be met. [Ref 3].

A less reliable method, of linking the read values to the temperature scale, can be to rely on the resistor manufacturer's stated tolerances, e.g. Class A, but do not forget that the complete sensor will add increased uncertainty. [Ref 4].

Pentronic's final inspection of Pt100/Pt1000 sensors is normally done in an ice-water bath using a reference sensor that is regularly calibrated in the accredited laboratory and thereby maintains traceability. Each supplied unit's test result at 0 °C is documented with a test certificate in accordance with EN 10204 3.1. The certificate is displayed on the Pentronic website. Look for Test Certificates under Services or Temperature Sensors. The sensor's ID number or our order number will take you to your test certificate, which is anonymised. If the platinum sensor is approved in accordance with Class A at 0 degrees, it will probably meet Class A even at higher temperatures. There is no extra charge for the test certificate.

However, if you want to be totally certain then accredited calibration at additional points is necessary. [Ref 4]

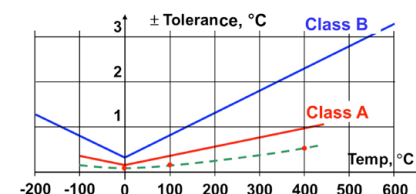


Figure 3. The diagram shows a typical behaviour of a platinum sensor in IEC Class A (the green dashed line). Three calibration points are shown (marked in red) within the interval 0–400 °C. Platinum is so stable that the points are sufficient to define the measurement properties within the whole range. See heading Calibration above discussing measurement uncertainty in the points.

Tolerance classes for Pt resistors				Tolerance classes for complete Pt sensors			Tolerance value at temperature T [°C]
Wirewound (W)		Film type (F)		Tolerance class	Temperature range [°C]		
Tolerance class	Tempera- ture range [°C]	Tolerance class	Tempera- ture range [°C]		Wirewound (W)	Film type (F)	
W 0.1	-100 – 350	F 0.1	0 – 150	AA	-50 – 250	0 – 150	± (0.1 + 0.0017· T)
W 0.15	-100 – 450	F 0.15	-30 – 300	A	-100 – 450	-30 – 300	± (0.15 + 0.002· T)
W 0.3	-196 – 660	F 0.3	-50 – 500	B	-196 – 600	-50 – 500	± (0.3 + 0.005· T)
W 0.6	-196 – 660	F 0.6	-50 – 600	C	-196 – 600	-50 – 600	± (0.6 + 0.01· T)

Figure 2. The tolerance classes and measuring ranges for platinum resistors that are wirewound and of film type (the orange field) and for complete temperature sensors (in blue). The grey column shows the expressions for the tolerances within each respective measuring range. |T| is the temperature value regardless of sign.

References see www.pentronic.se > News > Pentronic News > Pentronic News Archive
[Ref 1] See Pentronic News 2009-4 p 4
[Ref 2] See Pentronic News 2012-4 p 2
[Ref 3] See Pentronic News 2009-5 p 4
[Ref 4] See Pentronic News 2011-5 p 4

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