Following a brief presentation of the construction and applications of the thermocouple in Lesson 6, in this issue the temperature school will discuss the resistance thermometer with a focus on the Pt100. In the next issue of *Pentronic News* we will conclude the current series of the temperature school with a lesson on quality assurance and calibration.

LESSON 7 THE PT100 – ITS CONSTRUCTION AND APPLICATIONS

THE PLATINUM RESISTANCE THERMOMETER

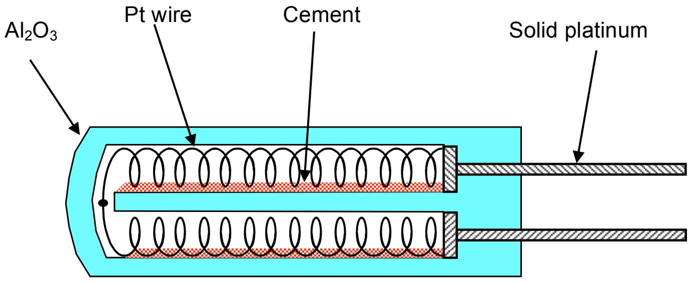
The first theories about resistance thermometers were proposed as early as 1891 by H C Callendar. The basis is that all metals change their resistance according to the temperature. The noble metal platinum is one of the most stable materials known, and is therefore suitable for temperature measurement.

The platinum sensor remains stable over a long period of time and is characterised by high accuracy. Its limitations compared with a thermocouple are a closer temperature range and a mechanically more sensitive construction with a longer response time.

WIREWOUND RESISTORS AND THINFILM RESISTORS

A wirewound Pt100 resistor can be illustrated by the adjacent diagram. In this construction, the platinum wires have the highest possible freedom of movement and thereby have reliable electrical properties. However, this construction is sensitive to mechanical influence and also requires a complex production process that affects its cost.

Nowadays thinfilm resistors are fabricated in slightly different ways but the main principle is that the platinum resistance loop is instead patterned onto or etched out from a substrate consisting of a ceramic plate. This technique gives the resistor considerably worse stability but the simplified production process also comes with a lower cost.



PROTECTION TUBE AND PROBE TIP

A Pt100 sensor in a process always consists of a resistor encased in some sort of protection tube. The design of this tube has a great influence on the sensor's properties and is basically customised to whatever resistor is required. The resistor's dimensions can be fitted into a length ranging from 2 to 30 mm and a diameter of 0.5 to 3 mm. The resistor can be cylindrical or "box" shaped.

It is sometimes possible to find cylindrical resistors that fit precisely into a protection tube without troublesome air pockets being created. This is an ideal situation. Normally, the respective measurements are not a good match, and steps must be taken so that the measurement performance is not worsened. One method is to place the resistor inside a metal casing that is customised to the protection tube's inner diameter (Figure 2). Another way is to use a heat-conductive paste that does not damage the resistor and its platinum resistance (Figure 6).

An alternative recommended by standards is to use a reduced probe tip. (Figure 5).

FIGURE 1

Normal

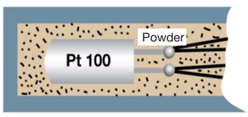
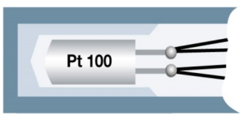


FIGURE 2



For better heat transfer

FIGURE 3

Normal

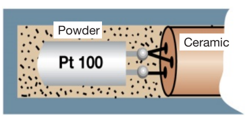
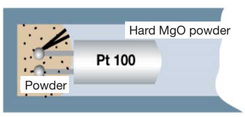


FIGURE 4



For vibrations at high temperatures

FIGURE 5

For better heat transfer

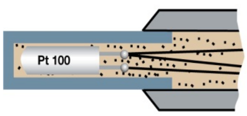
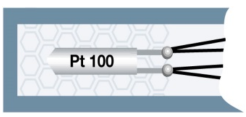


FIGURE 6



For strong vibrations at limited temperatures

At left are three common probe tip constructions available on the market. At right are three improved versions, which can be used for more reliable measuring or when more difficult environments are involved.

Example of a DIN standardised industrial Pt100 model.

AREAS OF APPLICATION AND STANDARDS

The most common industrial resistor has a resistance of 100 ohms at 0 °C - R(0) – and is called the Pt100. There are resistors with other R(0) values. R(0) = resistance value at zero degrees. The Pt1000 is common, especially in the plumbing and white goods industries. Other R(0) values also occur but to a lesser extent. The sensitivity and tolerances of these versions are the same as for the Pt100.

In Europe we use the standard IEC 60751 (2008). The USA and Japan set their own standards for Pt100s after there had been sufficient time to improve the production of platinum, so that their demands for the purity of the platinum could be set higher.

The practical consequence is that sensors from Japan or the USA will show higher values used with a European instrument.

However, nowadays the IEC standard, which has a strong position in Europe, has for competitive reasons also gained ground in the USA and Japan.

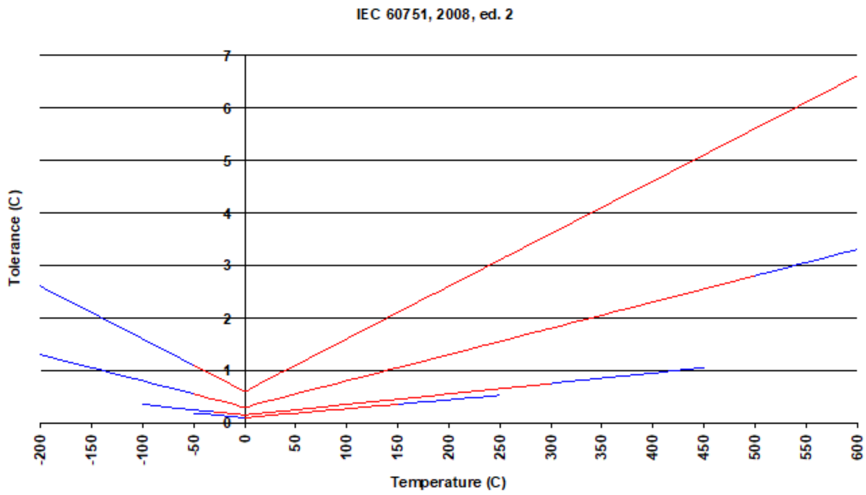
TOLERANCES AND CLASS DIVISIONS

Pt100 sensors are classified according to IEC 60751 (2008) in four classes: AA, A, B and C. See the table below, which gives the tolerances in °C. The different tolerance classes vary because the IEC permits varying degrees of purity in the platinum alloy. The European national standards, such as DIN 43760, follow the IEC.

The above table shows the tolerance classes with their associated ranges for wirewound and thinfilm resistors respectively. The tolerance level as a function of the temperature is shown in the column “Tolerance values”, where the permitted deviation in 0 °C is also given by the expression’s first term. |t| represents the temperature value regardless of the sign, i.e. the tolerances are symmetrical around 0 °C within the permitted temperature range. The slope of the tolerance curve is expressed by the coefficient before the temperature |t| which is expressed in °C/°C. The temperature of -196 °C has been used instead of the previous -200 because the end point should be easy to calibrate and this is normally done in boiling nitrogen, whose boiling point is very close to -196 °C.

IEC 60751 (2008) tolerance classes	The relevant temperature ranges (°C) for complete temperature sensors		Tolerance values °C
	Wirewound resistor	Thinfilm resistor	
AA	-50 to 250	0 to 150	± (0,1 + 0.0017 I t I)
A	-100 to 450	-30 to 300	± (0,15 + 0.002 I t I)
B	-196 to 600	-50 to 500	± (0,3 + 0.005 I t I)
C	-196 to 600	-50 to 600	± (0,6 + 0.01 I t I)

The IEC 60751 tolerance classes for integrated temperature sensors with Pt100 resistors in wirewound and thinfilm formats respectively. Note that other tolerances and temperature ranges can be used as long as you clearly state the situation that applies between the manufacturer and the user.



The tolerances of Pt100s according to IEC 60751 (2008) shown in graphic form. As a comparison, the positive tolerance limits according to Class 1 for types K and N thermocouples have been added as a dashed line. However, the platinum resistance thermometer is much more stable than the corresponding thermocouple.

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