The economic advantages of noble metal thermocouples

The term 'noble metal' often makes people think of expensive materials. This also applies to noble metal thermocouples such as the most common models of types S, R and B. It is easy to become fixated on the purchase price but instead it is important to weigh in the life cycle cost. Then the economics of noble metal thermocouples are much better.

Types S, R and B thermocouples all contain noble metal. The highest stated operating temperature for a reasonably long operating time is usually 1350 °C for types R and S, whilst type B can be used up to 1750 °C. It is impossible to give an exact number of hours for the operating time within a specific tolerance interval. The local environmental conditions at the sensor's position are very important, as are the installation conditions. For example, the operating time for type B increases dramatically if you restrict the operating temperature down to around 1350 °C. There are almost no alternative standardised thermocouples for oxidising environments for operation at over 1200 °C. Since 2013, types C and A thermocouples (tungsten-rhenium compositions [Ref 1] are indeed included in the IEC standard for temperatures about and above 2000 °C, but primarily for use in vacuum environments.

Scrap value of the wires

As the name suggests, noble metals have a significant economic value. However, even used platinum wire, both with and without added doping materials (e.g. rhodium) can be refined and then reused, and is therefore repurchased by the manufacturers. This can significantly reduce the cost of the wire.

The market is dominated by two wire diameters, Ø 0.5 and Ø 0.35 mm, although other dimensions also exist. Ø 0.5 mm wire contains twice as much material as the thinner version per unit of length because the volume is double. A thicker wire will give greater lifespan at the higher end of each respective temperature interval because there is more material for the surrounding environment to attack and "use up" and thereby to gradually transform the pure platinum into other products, which can have a different sensitivity, or merely to deplete part of the area of the wire. When none of the electrically conductive original material remains, the instrumentation perceives this as a break in the wire.

Defects in crystal structures and impurities that are unavoidably present from the start in newly manufactured wire both affect the sensitivity, which is also called the Seebeck coefficient. When the wires are drawn down to thinner and thinner dimensions, the affected material is "smeared" farther out along the wire. This will probably lead to a larger proportion of the temperature gradient [Ref 2] encompassing the affected material, which increases the measurement error. This applies even more to sheathed base metal thermocouples. See Figure 1.

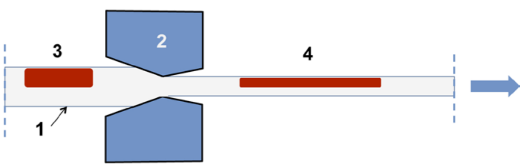

Figure 1. To suit the diameter to commercially used measurements, a thermocouple wire or a metal-sheathed thermocouple (1) is drawn through draw plates (2) equipped with smaller and smaller holes. An unavoidable impurity (3) from the alloy melt will also therefore in principle be reduced radially according to the draw plate hole. This thereby increases the length of both the impurity and the wire. See (4).

K and N the most robust

Ordinary types K and N thermocouples become more and more unreliable when used at very high temperatures. The limit for the base metal thermocouples is usually set at 1000 – 1200 °C. The term 'base metal' already indicates that the alloys used in the wires are much more likely to react to their surroundings than is the case with noble metals, which first start to react at higher temperatures than those just mentioned. This predisposition to react is one of the factors that determine the temperature limits.

In the cases when priority is placed on rapid response time and robustness, and when the operating temperature is not too high, types K and N metal-sheathed thermocouples can still be preferable over the "slower" types S, R and B thermocouples, all of which must be sheathed in very pure ceramic, Al_2O_3, which makes them more susceptible to mechanical damage and heat stresses when they are replaced during operation. See Figure 3. According to the standard, types R/S have a tolerance of ±3 °C at 1200 °C whilst types K and N are at ±9 °C. However, types K and N degenerate quickly at this temperature with a resulting high maintenance cost. See Figure 2.

Thermocouple type	Tolerance before use, °C	
R and S	T < 1100: 1100 < T < 1600:	±1 [±1 + 0,003 • (T-1100)]
B	600 < T < 1700:	± 1,5 or 0,0025 • T
K and N	1000 < T < 1200:	± 2,5 or 0,0075 • T

Figure 2. A comparison of tolerances in accordance with IEC 60584:2013 for the relevant thermocouple types and temperature intervals. Note that the tolerances only apply to unused thermocouples.

To summarise, noble metal thermocouples are not necessarily very expensive when their scrap value, lifespan and maintenance costs are included in the total calculation. In addition, noble metal thermocouples have much better measurement performance than types K and N.

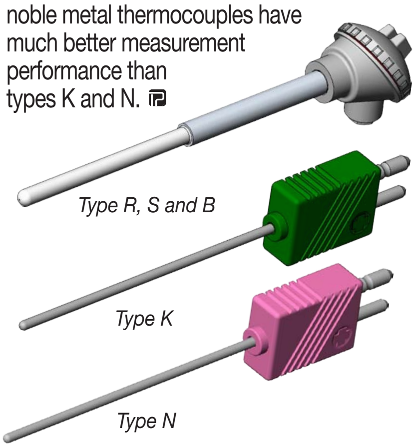

Figure 3: The noble metal wires for types S, R and B thermocouples must be sheathed in very pure ceramic to protect them from the measuring environment. The insulation consists of, for example, a two-bore rod surrounded by a closed protection tube. In metal-sheathed thermocouples like types K and N, the wires are integrated in densely packed magnesium oxide acting as electrical isolation, which in its turn is enclosed in the metal sheath. This compact construction gives excellent heat transfer with a short response time compared with the ceramic construction.

References see www.pentronic.se > News > Pentronic News > Pentronic News Archive
[Ref 1] Pentronic News 2014-2 p 4
[Ref 2] Pentronic News 2012-1 p 4

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