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Thermocouples – Minimising Drift

To achieve consistent and reliable readings from a thermocouple over its service life (1), it is necessary to minimise the drift that steadily reduces the output. Drift is generally caused by contamination of the Pt limb. Contamination can be built in, acquired in service or originate from the thermocouple's RhPt alloy limb.

The user must ensure that a thermocouple is not contaminated before or during service. Cleanliness is essential. It is critical not to build in contamination such as metal swarf derived from end caps, etc. Burning-out ceramics and wiping wires with industrial methylated spirits are both good practices to follow.

The upper operating temperatures of Pt thermocouples are sufficiently high to destabilise lower grade ceramics, releasing metallic elements from their oxides. Thus, the preferred insulation for both twin bore and outer sheaths is high purity recrystallised alumina.

Another source of contamination comes from the furnace load; metallic vapours in vacuum brazing furnaces can condense on the thermocouple and cause damage. It is important that the design of the installation protects the thermocouple with suitable physical barrier layers of metallic and ceramic closed end tubes. However, while additional layers prolong the life of the couple, they do this to the detriment of the response rate and accuracy. Thick metal cladding, which conducts heat to the furnace wall, can act as a 'heat sink', attracting and condensing contamination.

Rhodium Drift

This is the transfer of Rh from the alloy limb to the Pt limb. The metal transfer is possible because Rh oxide is volatile above 1200°C and the gas diffuses or convects to cooler areas where it condenses. It is not very stable and, once dissociated, the Rh metal contaminates the Pt limb. Rh oxide can often be seen as a black layer covering the alloy limb. It indicates the in-service temperature contour from 800 to 1200°C. (The blackening can be removed by resistance heating the alloy limb wire to 1450°C in air.)

Reducing convection and diffusion using physical barriers reduces the Rh drift, for example, by using one-piece ceramics. An alternative approach is to limit the formation of Rh oxide by reducing the available oxygen. However, very low oxygen pressure can destabilise other harmless oxides, reducing them to harmful contaminants, for example, silicon.

The rate of Rh drift is dependent on the physical and thermal geometry and the peak temperature of an installation. It is recommended that at first users should recalibrate more frequently in order to find the rate of drift and hence the thermocouple's life expectancy.

The various forms of contamination or Rh loss result in wire that is no longer homogeneous along its length. The lack of homogeneity can cause a problem when the thermocouple is recalibrated, as the temperature profile in the calibration furnace is unlikely to be the same as the temperature profile in the user's furnace. In this case, different lengths of the wire will be responsible for producing the voltages during both calibration and service. The lack of homogeneity can also explain the differences seen when comparing results from different calibration methods or from different laboratories.

There are also open circuit faults and compensating circuits that use compensating leads. These will be discussed later. For accuracy, users should ensure that:

- the environment is clean
- the thermocouples are not stressed
- they are annealed before use, and
- high quality ceramics are used and mechanical damage is avoided.

R. WILKINSON

Reference

1 R. Wilkinson, *Platinum Metals Rev.*, 2004, **48**, (2), 88

Roger Wilkinson is a Senior Materials Scientist at Johnson Matthey Noble Metals in Royston, U.K. He has worked with platinum thermocouples since 1987 in manufacturing, calibration and customer technical support.