Thermocouple Reference Tables

AN INTERNATIONAL STANDARD ACCEPTED

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The accurate measurement of high temperatures made possible by the use of rhodium-platinum thermocouples depends upon the use of reference tables which are themselves not only accurate and reliable but are accepted throughout the world of science and technology. For many years differences were to be found between the tables issued respectively by British and American standardising bodies, but a move to eliminate this confusion and to provide internationally agreed tables was made jointly by Johnson Matthey and Engelhard Industries in 1965 in an approach to the British Standards Institution and the National Physical Laboratory. This led to a collaborative investigation by the National Bureau of Standards in Washington, the National Research Council of Canada and the N.P.L. and to the re-calibration of couples supplied by seven leading manufacturers. An account of this work was published in this journal in 1972 (1).

The resulting reference tables, based upon the 1968 revision of the International Practical Temperature Scale (IPTS–1968), were adopted and published in 1973 by the British Standards Institution as B.S. 4937 and in identical form by the National Bureau of Standards as Monograph 125, these replacing the older sets of tables (B.S. 1826 of 1962 and N.B.S. Circular 561 of 1955) which showed substantial differences, more particularly between N.B.S. 561 and the new tables (2).

The next move was to secure wider international agreement and so to promote the interchangeability of thermocouples and to eliminate a common source of error and confusion, but there has been some reluctance on the part of many of the major industrialised nations to amend their own standards until such international agreement could be achieved. This was a matter for the International Electrotechnical Commission (IEC) based in Geneva and in 1974 a committee was formed for this purpose. Now an IEC Standard—584–1 "Thermocouples, Part I Reference Tables" has been issued. These tables are in agreement with both B.S. 4937 and N.B.S. 125, and the letter designation employed in those standards is confirmed:

Type S: 10 per cent Rhodium-Platinum : Platinum

Type R: 13 per cent Rhodium-Platinum : Platinum

Type B: 30 per cent Rhodium-Platinum : 6 per cent Rhodium-Platinum

The remainder of the standards cover the base metal combinations iron: copper-nickel, copper: copper-nickel, nickel-chromium: copper-nickel and nickel-chromium: nickel-aluminium.

The following countries represented on the IEC committee voted in favour of publication of this new international standard:

Australia	Holland	Sweden
Austria	Hungary	Switzerland
Belgium	Israel	Turkey
Bulgaria	Japan	United Kingdom
Czechoslovakia	Poland	United States of America
France	Republic of South Africa	
Germany		Yugoslavia

This step forward towards international unification is of great importance, and it is to be hoped that all national bodies will now amend their standards—particularly those based upon the old N.B.S. 561—to fall into line with IEC 584–1. The general adoption of these tables will be of great value in eliminating a common source of error and of confusion between workers in different countries. A further advantage is that the new values show a much smoother progression, providing an increased accuracy of interpolation.

Further work is being carried out by an IEC Technical Committee (65B) on a set of internationally acceptable tolerances for all seven thermocouple combinations, and these should eventually be issued as Part II of the 584-1 standard.

References

1 T. J. Quinn and T. R. D. Chandler, *Platinum Metals Rev.*, 1972, **16**, (1), 2–9

2 P. H. Wells, *Platinum Metals Rev.*, 1973, **17**, (3), 96–97

Tantalum Clad Rhodium-Platinum Thermocouples

LARGE DECALIBRATIONS INDUCED BY UNFAVOURABLE COMBINATION OF MATERIALS

The robustness and resistance to mechanical and thermal damage displayed by metal sheathed thermocouples have prompted their use in many arduous industrial environments, where the conventional, alumina insulated, alumina sheathed devices display limited durability. Great care must be taken, however, in the design and construction of metal sheathed thermocouple probes in order to minimise thermoelectric instability. In particular, the materials of construction must be chemically compatible at the temperature of operation, and a recent paper by T. G. Kollie, W. H. Christie and R. L. Anderson (*J. Less Common Metals*, 1978, **57**, (1), 9–27) illustrates very clearly how an incorrect choice of materials can lead to substantial reaction-induced decalibrations.

During experiments conducted at the Oak Ridge National Laboratory, platinum: 10 per cent rhodium-platinum and 6 per cent rhodium-platinum: 30 per cent rhodium-platinum thermocouples alumina insulated and encased within a pure tantalum sheath, were heated at temperatures up to 1330°C in an atmosphere of pure helium. After only a few hours at temperature, decalibrations equivalent to −152°C, and −11°C respectively were observed in the two assemblies. Subsequent metallographic examination and microprobe analyses showed that severe reactions had occurred at the interface between the alumina insulation material and the thermocouple wires, resulting in the presence of up to 27 atomic per cent aluminium in the thermocouple limbs.

It is well known (1) that platinum will react with most refractory oxides under conditions which maintain a low oxygen potential in the surrounding environment, the driving force being the extremely high affinity of platinum for the metal released upon decomposition of the oxide. In the devices described in the Oak Ridge paper, the tantalum sheath itself would be expected to act as a continuous "getter" for oxygen and thus allow the platinum-alumina reaction to proceed unhindered.

A Successful Combination

If the same thermocouples were sheathed with a material exhibiting little or no affinity for oxygen, then the oxide-platinum reaction becomes self stifling, in that the slightest tendency towards reaction raises the oxygen partial pressure in the surrounding environment to the equilibrium value. A practical embodiment of this argument is the 5 per cent rhodium-platinum sheathed 6 per cent rhodium-platinum: 30 per cent rhodium-platinum thermocouple, which, when provided with an inert gas internal atmosphere, decalibrates by only −5°C, after 500 hours at a temperature of 1450°C (2). This combination of sheath and thermocouple resulted from a detailed consideration of material compatibility, high temperature strength and mechanical durability; and in recent years it has proved to be an accurate means of sensing temperatures in many industrial processes.

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References

1 A. S. Darling, G. L. Selman and R. W. E. Rushforth, *Platinum Metals Rev.*, 1970, **14**, (2), 54–60

2 G. L. Selman and R. W. E. Rushforth, *Platinum Metals Rev.*, 1971, **15**, (3), 82–89