May 1972

B72-10176

NASA TECH BRIEF

Lewis Research Center

Long-Term Drift of Thermocouples at 1600 K

Thermal electromotive-force changes for 30 commercially available noble- and refractory-metal thermocouples have been determined in air, argon, and vacuum, at 1600 K for exposures up to 10,000 hours.

Various areas of research involving material, component and complete-system studies require the use of thermocouples in tests lasting for long periods of time. It is important that the temperature-emf relation, established by calibration, is maintained, or that it changes in a negligible or predictable manner over the test time period. Systematic deviation from the original calibration, over a period of time, is commonly called drift. This drift may be associated with change in the composition or structure of the thermocouple materials when exposed to a thermal gradient. Changes in chemical composition occur by exchange of material between the wires and also between the wires and the surrounding media. Some of the mechanisms involved are diffusion, chemical action, selective evaporation of an alloy constituent, or evaporation form one element and subsequent deposit and combination with the other.

The thermocouples tested were 87Pt13Rh/Pt, 70Pt-30Rh/94Pt6Rh, and 95W5Re/74W26Re. Wire sizes ranged from 0.3 to 1.1 mm diameter with 0.5 mm being the most common size. The thermocouple-assembly materials, construction and usage were selected in advance, to minimize drift. Selection was based on the best judgment that could be exercised from results previously reported by others. Thermocouple materials were of the best grade commercially available and the insulators used were high-purity alumina.

Chemical and structural changes in the materials were determined by solids mass spectrometry, photomicrography, and hardness testing. The noble-metal thermocouples exhibited large grain growth, while the refractory-metal thermocouples did not. Post-test examination also showed that the main impurities commonly picked up by both the noble-metal and refractory-metal wires were iron and silicon.

This investigation defined and examined some of the primary variables involved in long-term thermoelectric stability of thermocouple assemblies. The test results may be used in making a choice for an application from among the specific assemblies examined, and the investigation techniques can serve as guidelines for future studies of other thermocouple systems. For instance, the results indicated that it is preferable to use a thermocouple wire size as large as practical to minimize drift by minimizing contamination from impurities. For use in argon for a few thousand hours duration, the choice indicated is the noble-metal thermocouple because the drift during this time period is much less than for the refractory-metal thermocouple. To further minimize drift, the choice of the type of noble-metal thermocouple pair would favor the pair which contains Pt-Rh in both legs. For longer durations in argon (up to 10,000 hours), the indicated choice is the refractory-metal thermocouple because, although the magnitude of the drift was the same for both the noble-metal and refractory-metal thermocouples (-22 K), there was less scatter in the data for the refractory-metal type. In vacuum applications, the refractory-metal thermocouples are the better choice because many of the noble-metal thermocouples failed due to open circuits. For air, where the choice would be to use the noble-metal thermocouple because of the oxidizing atmosphere, it was found that the noble-metal thermocouple was very stable (-5 K-drift for 10,000 hours).

(continued overleaf)

Notes:

1. The following documentation may be obtained from:
   National Technical Information Service
   Springfield, Virginia 22151
   Single document price $3.00
   (or microfiche $0.95)

   Reference: NASA-TN-D-7027 (N71-14843) Thermal Electromotive Force Change for Some Noble-and Refractory-Metal Thermocouples at 1600 K in Vacuum, Air and Argon

2. Technical questions may be directed to:
   Technology Utilization Officer
   Lewis Research Center
   21000 Brookpark Road
   Cleveland, Ohio 44135
   Reference: B72-10176

Patent status:

No patent action is contemplated by NASA

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(LEW-11471)