April 1970

Brief 70-10197

AEC-NASA TECH BRIEF

Cryogenic Thermocouple Calibration Tables

The problem:

To develop thermocouple calibration standards for materials commonly used at very low temperatures. In the past, thermometry below the temperature of liquid oxygen (90°K) has been severely limited by the lack of accurate calibration tables.

The solution:

Thermocouple tables that will make possible calibration standards for frequently used low-temperature thermocouple material combinations.

How it's done:

A definitive standard for thermocouple calibration in the cryogenic range is presented in three separate National Bureau of Standards (NBS) reports, nos. 9712, 9719, and 9721. In report no. 9712, experimental tests between 4° and 280°K are described for the following thermocouple materials: Chromel, copper, "normal" silver, platinum, silver-28 atomic (at.) % gold, constantan, Alumel, and gold-(0.02, 0.03, 0.07) at.% Fe. A number of thermocouple combinations can be made from these materials, the four most important being copper vs constantan, Chromel vs constantan, Chromel vs Alumel, and Chromel vs gold-0.07 at.% iron. The results of the last combination are of particular interest for measurements made near the temperatures of liquid hydrogen (20°K). This report also contains a description of the calibration cryostat used in obtaining the data. In addition, the special methods of measurement and data analysis are briefly discussed, together with simple illustrations of the measuring schemes. Tables and graphs of the thermoelectric voltage and thermopower for the four combinations are included in the report.

In report no. 9719, thermovoltage, thermopower, and thermopower derivative are presented in tabular and graphical form for the common low-temperature thermocouple materials vs platinum and "normal" silver (Ag-0.37 at. % Au). Since the thermopower of platinum depends critically on physical imperfections and chemical impurities, it is not a suitable thermoelectric reference material below about 50°K. For this reason, Ag-28 at. % Au is used as the standard reference material below 50°K. At the time of the experimental work discussed in this report a usable selection of Ag-28 at. % Au was unavailable, thus "normal" silver was used. A single wire of the Ag-28 at. % Au was compared thermoelectrically to platinum and "normal" silver. The results of these comparisons may be used to obtain interim values of the thermoelectric data for thermocouple alloys vs Ag-28 at. % Au.

In report no. 9721, the thermovoltage, thermopower, and thermopower derivative are also presented in graphical and tabular form for (a) Chromel, copper, platinum, and "normal" silver vs gold-0.02 at. % iron, and (b) copper vs gold-0.07 at. % iron. Thermoelectric comparisons are made graphically for Chromel, Alumel, constantan, "normal" silver, and platinum.

The combinations described in the NBS reports are the miscellaneous and comparison types that have not been widely used. In some cases, however, these combinations may have significant advantages over the more widely used ones.

Notes:

1. This information should be of interest to industrial, medical, and research users of cryogens.
2. Copies of the three NBS reports can be obtained from:

   Technology Utilization Officer
   AEC-NASA Space Nuclear Propulsion Office
   U.S. Atomic Energy Commission
   Washington, D.C. 20545
   Reference: B70-10197

(continued overleaf)

Patent status:

No patent action is contemplated by the AEC or NASA.

Source: L.L. Sparks, R.L. Powell, and W.J. Hall of
Cryogenics Division
Institute for Basic Standards, NBS
under contract to
Space Nuclear Propulsion Office
(NUC-10551)