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Ernest O. Lawrence Radiation Laboratory

NEEDS FOR HIGH TEMPERATURE STANDARDS

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Leo Brewer

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Needs For High Temperature Standards

Leo Brewer

Inorganic Materials Research Division,
Lawrence Radiation Laboratory
and Department of Chemistry,
University of California,
Berkeley, California

Because of the experimental difficulties associated with accurate measurements at high temperatures, there is a particular need for many types of standards and for independent checks of standards at a number of different laboratories.

The most important standard is, of course, a temperature standard. The high temperature thermodynamic scale is based on the Planck radiation equation, but absolute intensity measurements are so difficult that the Planck equation is always used to determine temperature by a comparison method. In principle, one could compare the intensity of emission in a narrow wavelength interval of the system in question with the intensity of emission in the same wavelength interval for a black body system at the melting point of gold. Several countries including Japan have been using gas thermometry to fix the gold point on the thermodynamic temperature scale, and the gold point is the primary temperature point for fixing high temperatures through use of the Planck equation. However, the emission of light is weak at the gold point, and there are difficult problems of obtaining black body conditions. It is not feasible to carry out the comparison with the gold point emission in routine temperature determinations, and secondary standards are necessary. The melting points of refractory metals such as platinum,

iridium, etc. provide suitable secondary standards. However, the use of these secondary standards requires the availability of pure materials, and well prescribed conditions to insure black body conditions and temperature uniformity. Although such secondary standards are widely used, standard tungsten ribbon lamps provide an even simpler secondary standard, and such lamps are available in several countries with certified standardizations based ultimately upon comparison with the gold point using the Planck equation. In addition, calibrated thermocouples and optical pyrometers can be obtained in several countries. However, even in the most carefully organized national standardizing laboratories, changes in personnel and procedures may result in unsuspected systematic errors. This has happened in several countries in recent decades. These errors were uncovered by comparison with standard laboratories in other countries. Because of the seriousness of such systematic errors of calibration by national standards laboratories, it is very important that the various standards laboratories make regular checks against one another to uncover such errors quickly before the accuracy of too many experiments have been placed in jeopardy.

In addition to temperature standards, heat capacity or enthalpy standards are very important in checking calorimetric equipment for systematic errors. Alumina is now such a standard. A number of different laboratories have made careful measurements of the heat capacity of alumina over a wide temperature range, and it appears that it is feasible to prepare alumina samples that are pure enough and well enough characterized thermodynamically to be used for checking enthalpy changes in a calorimeter. There is a need for additional materials for use not only

under oxidizing conditions but also under reducing conditions. Here again this development is an effort which requires cooperation among laboratories of many countries. The importance of checking between different laboratories can be illustrated by the recent discovery of a systematic error in absolute pressure measurements in the United States. The absolute pressure has been measured in the low pressure region using a McLoed Gauge. All of the laboratories in the United States that were making crossection measurements by beam scattering methods used gauges with tubes of the same crossection, and all used liquid nitrogen traps in a consistent manner. They obtained consistent crossection measurements when compared with other laboratories in the United States using the same technique, but there was a large difference compared to other techniques. It was discovered that the flow of mercury vapor from the McLoed Gauge to the liquid nitrogen trap pumped enough gas to result in an appreciably lower pressure within the gauge compared to the system being studied. If the results had been compared with results in other laboratories even using the same technique, this error would have been discovered sooner since the pumping effect depends upon the diameter of the tube from the gauge to the system. In other countries it would be unlikely that the same size would have been used as in the U.S.

Another important high temperature standard is a vapor pressure standard. It is difficult to measure accurate absolute vapor pressures especially by some of the convenient new methods such as the mass spectrometer. If the apparatus could be calibrated by a material of known vapor pressure, many systematic errors could be eliminated. A variety of materials are needed because of the wide temperature ranges

of interest and the variety of materials used for containers. If very careful measurements were carried out on a few standard materials and confirmed in a number of different laboratories in different countries, these materials could then be widely used to determine the vapor pressures of other materials by a comparison method.

It can be seen that all of these standards serve a similar purpose. Absolute measurements are very difficult to carry out accurately. It requires checks among many different laboratories to be sure that systematic errors have been eliminated. Once a standard has been established, other workers are relieved of the need for the very time consuming absolute measurements and can use their time usefully for measurements by a comparative method on a greater number of substances.