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EQUILIBRIUM WATER VAPOR PRESSURE  
OVER ADHESIVES AND EPOXIES

C. Colmenares and L. McDavid

May 19, 1975

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EQUILIBRIUM WATER VAPOR PRESSURE  
OVER ADHESIVES AND EPOXIES

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(Presented at the 15<sup>th</sup> meeting of JOWOG-12, June 18-21, 1974  
AWRE, Aldermaston, England)

A technique has been developed to measure the equilibrium water vapor pressure over adhesives, epoxies, and other organic materials as a function of temperature. A knowledge of the water vapor pressure is needed to define the driving force for the oxidation, by water, of metals such as uranium and thorium in contact with organic materials.

An apparatus has been built to measure the partial pressure of water over organic materials as a function of temperature. The method is based on the measurement of the diffusion of water vapor through a membrane that has a rather low permeability to water, such as mylar. On the upstream side of the membrane we have pressures that were in the 1 to 100 torr range, while in the downstream, or measurement side, the water concentration in the carrier gas (argon) varied from 10 to 100 ppm by volume. Water in the low partial pressure side of the membrane was detected using an electrolytic hygrometer. Figure 1 shows the details of the diffusion cell, and Figure 2 is a schematic representation of the complete system.

Calibration of the membrane was done by measuring the diffusion of water vapor through a  $5 \times 10^{-2}$  mm thick membrane, using either pure water or saturated salt solutions having well known water vapor pressures, at several temperatures.

These calibration measurements allowed the calculation of the permeability constant for the membrane as a function of temperature. The unknown partial pressure of water over the sample was calculated from the membrane permeability constant at a chosen temperature and the measured rate of permeation at steady state by the following formula:

$$p_2 = \frac{F \times C_2 \times Z \times 10^{-6}}{P \times A}$$

where, F is the carrier gas flow rate in cm<sup>3</sup>/s

p<sub>2</sub> is the unknown partial pressure of water in torr.

C<sub>2</sub> is the downstream concentration of water measured in ppm by volume.

Z is the membrane thickness in cm.

P is the permeability constant for the membrane in cm<sup>3</sup>/s - cm<sup>2</sup> - (torr/cm).

A is the membrane area in cm<sup>2</sup>.

The adhesive or sample to be tested was cast in the form of flat discs 20 cm in diameter and 1.27 cm thick, and was allowed to cure for at least 64 hours in air with a known and controlled relative humidity (10 to 50% RH). The moisture content of the samples to be tested varies as a function of the partial pressure of water in the atmosphere in which they are handled or allowed to cure. Therefore, we are measuring the partial pressure of water over a sample both as a function of temperature and of total initial water content. Water vapor pressures were measured in a temperature cycle from 20° to 80°C and back to 20°C. Because the amount of material tested was large, very little water was removed by permeation through the mylar membrane during the test.

Vapor pressure measurements have been made on samples of an epoxy (M-302), and two adiprene-base adhesives L-315 and LW-520. As an example, results for the LW-520 adhesive, cured in 10% RH air at 22°C (total moisture content ~0.25%), are shown in

Figure 3 as a plot of partial pressure of water versus  $1/T$ . The dotted lines in this figure represent the 90 confidence level limits. The slope of the plot in Figure 3 represents the heat of vaporization of water from the adhesive, and in this case it is  $37.14 \pm 1.42$  kJ/mol ( $8.88 \pm 0.34$  kcal/mol), as compared to the heat of vaporization of  $H_2O(l)$  going to  $H_2O(g)$  at STP which is 44.04 kJ/mol (10.52 kcal/mol). In this test, 8.1 mg were removed from the sample which contained a total of 808 mg total moisture (1%).

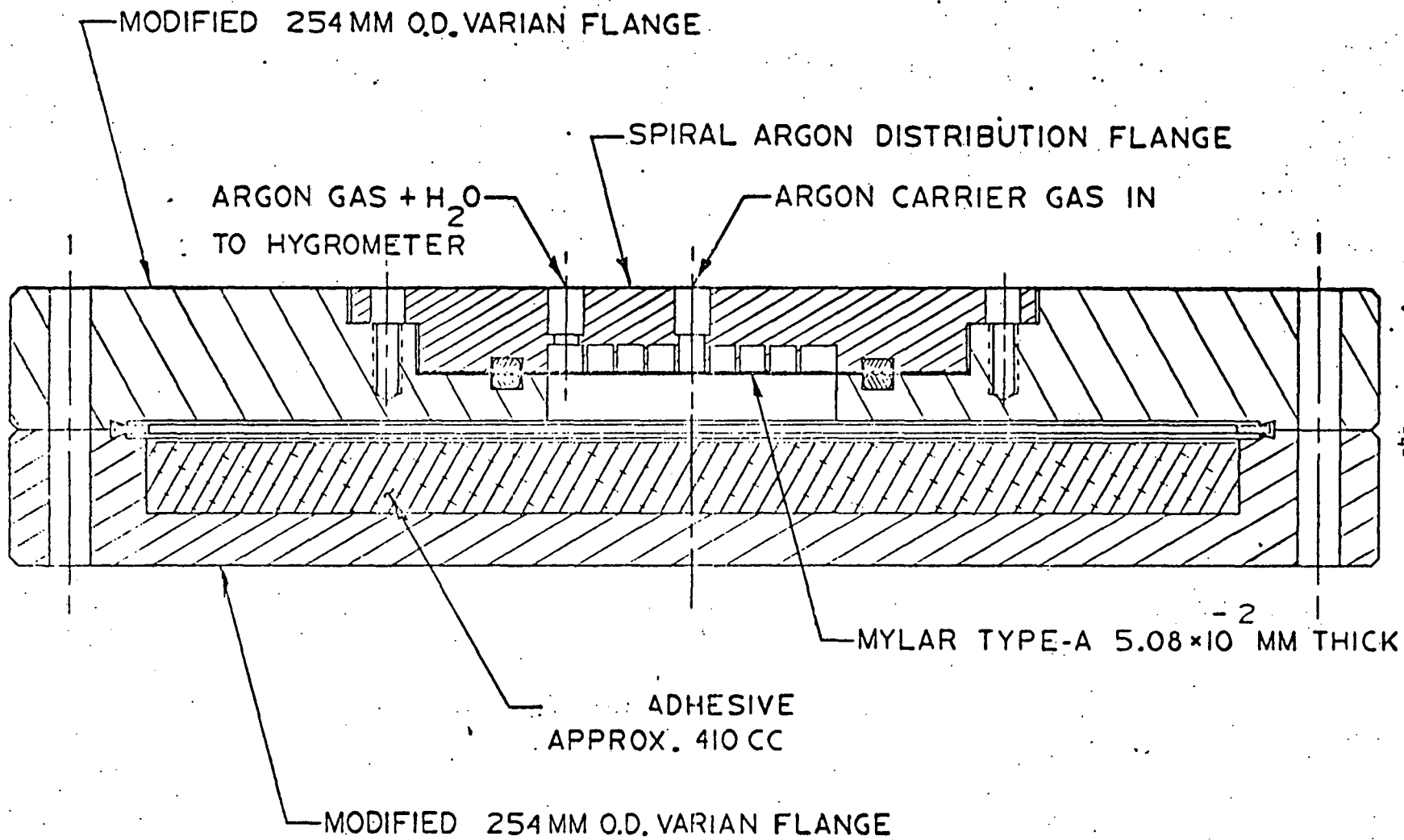


Figure 1. Diffusion Cell

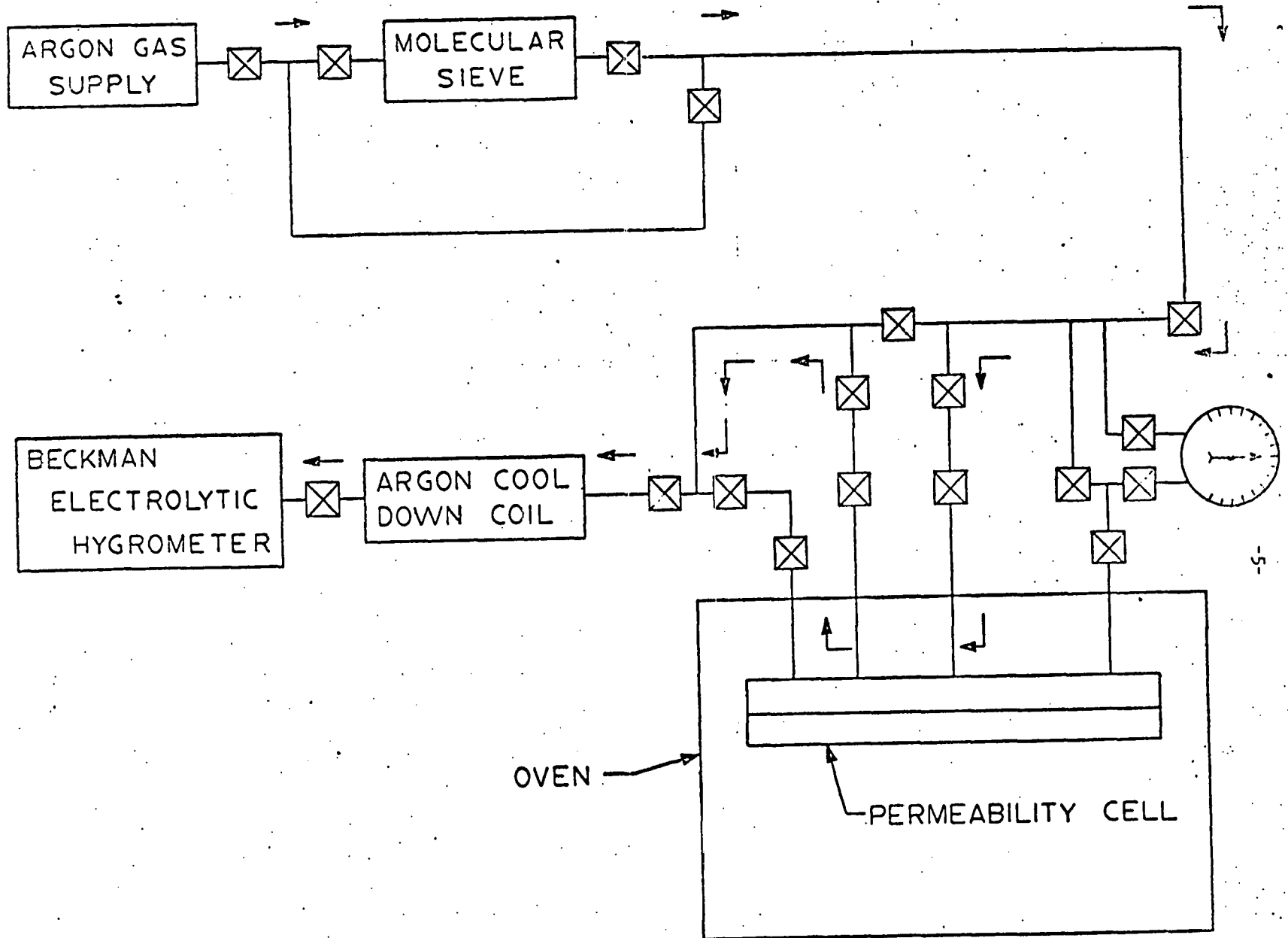


Figure 2. Flow Diagram of Apparatus.



ADIPREN LW-520

$\Delta H = 37.14 \pm 1.42 \text{ KJ/MOLE } ( 8.68 \pm 0.34 \text{ KCAL/MOLE } ) \quad 90.00\% \text{ C.L.}, \quad 8 \text{ D.F.}$

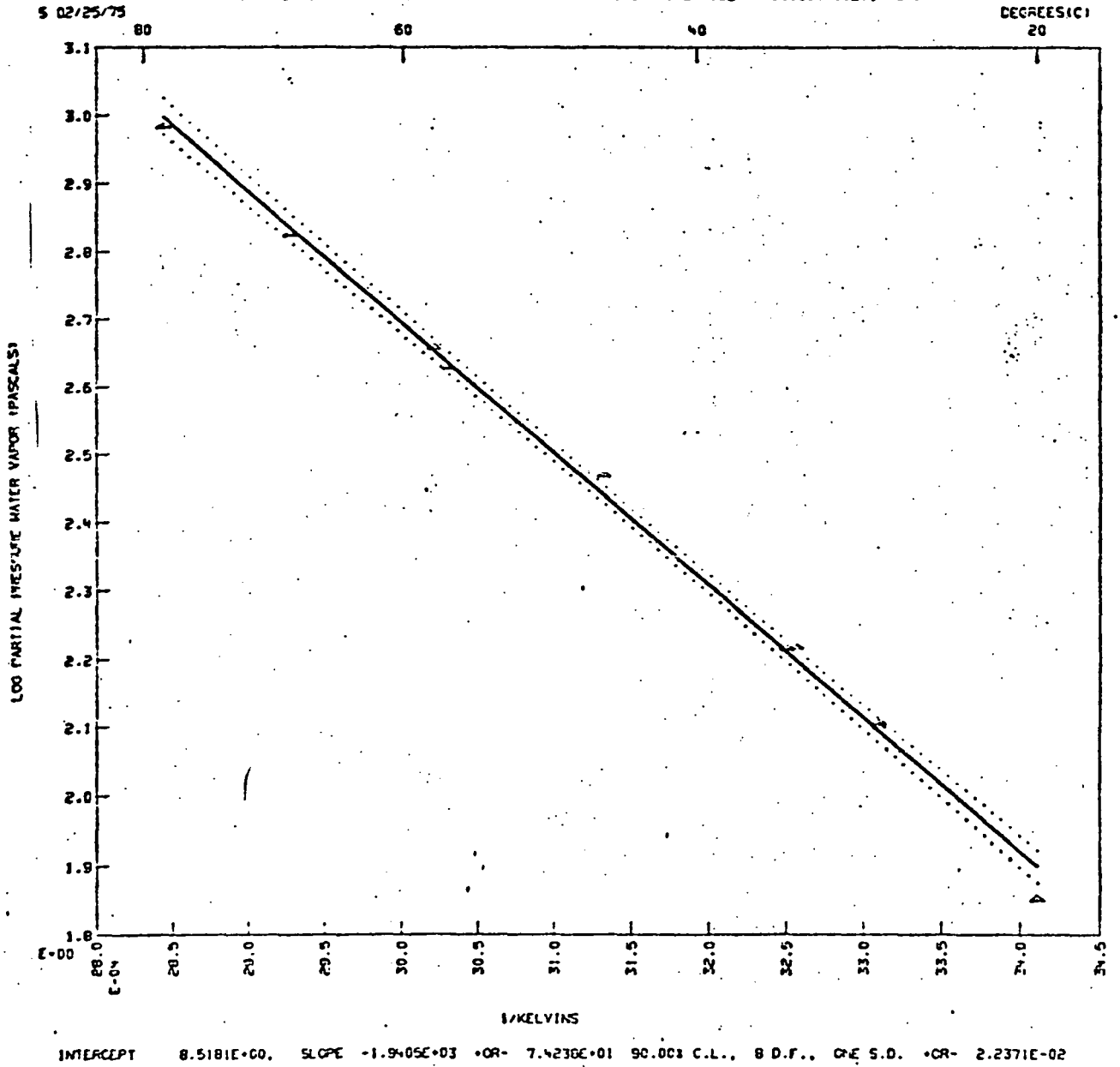


Figure 3. Vapor Pressure of Water Over a LW-520 Sample as a Function of Temperature

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