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Authors

Searcy, Alan W.
Schulz, David A.

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University of California

Ernest O. Lawrence Radiation Laboratory

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Alan W. Searcy and David A. Schulz

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

We have completed measurements by the torsion-effusion method[1] of apparent pressures of saturated tin vapor in a pressure range from below 10^{-8} to above 10^{-2} atmos. A factor f derived by Freeman and Searcy to correct for the effect of finite orifice channel lengths should bring all our measurements into agreement provided that the mean-free-path of the vapor is long relative to the orifice dimensions.[2,3]

Use of this factor f in the range of tin vapor pressures below 10^{-5} atmos does bring into agreement pressures calculated from forces measured with a variety of orifice diameters and lengths. But at higher pressures, the factor no longer brings the measurements into agreement either with each other or with a third law extrapolation of the low pressure curve. The divergence presumably occurs because the vapor no longer obeys molecular flow equations.

Over a range of vapor pressures that extends generally from about 10^{-4} to 10^{-3} atmos, but that depends somewhat upon the orifice geometry, the uncorrected pressures show a new, but well defined, dependence on orifice geometry. In this range each orifice yields apparent (i.e., uncorrected) pressures that are lower than the true vapor pressure by an amount that decreases only very slowly with temperature. To approximately the limits of experimental reproducibility, division of each apparent pressure by an empirical constant f' yields the true pressure curve over this range. The data collected for this pressure range demonstrate previously unrecognized gas flow characteristics. The empirical correction factor f' for this range of pressures depends only on the orifice length ℓ and not upon the orifice diameter provided that the diameter is smaller than a critical value d_c (Table I). Extrapolation of a plot of f' vs ℓ to $\ell = 0$ yields $f' = 1$. The data fit the equation $(1 - f') = 1.6\, \ell^{0.7}$.

The critical diameter for any given value of ℓ is that diameter which makes the correction factor f for molecular streaming conditions equal to f'. For tin vapor, d_c is nearly independent of ℓ for $0 < \ell \leq 3.2$ mm and is equal to $1.5 \pm .2$ mm. For four orifices with diameters equal to or larger than d_c, the correction factor of Freeman and Searcy brings the apparent pressure curves into excellent agreement with the true vapor pressure curve. In other words, for this kind of flow f' is restricted to the range between f and 1.

We conclude that a true pressure can be calculated from the force exerted by a vapor or gas that effuses under these flow conditions by either of two means: An orifice of short channel length may be used, in which case f' becomes nearly unity; or an orifice with finite ℓ and diameter greater than d_c may be used, in which case the data can be corrected by use of the factor of Freeman and Searcy.

Recent experiments with orifices of very short channels by Liepmann[4] and by Carlson,[5] who worked under the guidance of Gilles and Thorn, demonstrate that the ratio of the number of molecules that escape through an orifice to the pressure inside the orifice increases between the molecular streaming range and this new range of fluid flow. Our

TABLE I

Ratio f' of the Apparent Pressure to the Equilibrium Pressure as a Function of Orifice Length

Orifice Length (mm)	Orifice Diameter (mm)	Theoretical Value of f for Molecular flow [a]	Experimental Value of f' in New Region	Critical Diameter (mm)
.38	.78	.74	.86	1.6
.78	.79	.58	.65	
.78	.79	.58	.76	
.78	.36	.38	.73 .71	1.5
1.60	1.62	.58	.58	
1.61	.79	.39	.57	
1.64	.40	.25	.52	
1.64	.40	.25	.62 .57	1.6
3.23	.84	.26	.33	1.3

a) Ref. 2 and 3

results show that for thin orifices the corresponding forces exerted by escaping vapor are identical to those predicted by molecular flow equations. Any equation that reconciles the weight loss and force data must, therefore, require that $nv = n'v'$ throughout the transition range, where n is the number and v the average velocity of molecules that would effuse per unit time in the direction normal to the orifice axis if molecular flow equations were obeyed, while n' and v' are the actual number and actual average normal velocity.

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