

*M. F. Mason,<sup>1</sup> Ph.D.*

## A Note upon Barometric Pressure and Breath-Alcohol Analysis

---

A number of people concerned with and employing breath-alcohol testing devices have expressed uncertainty regarding the effects of changes in barometric pressure upon the results of analyses.

If a fixed volume of breath, measured or unmeasured, obtained and analyzed at existing *ambient* pressure, has been employed, the result is independent of barometric pressure. Thus, at a given concentration of alcohol in pulmonary arterial plasma, the amount of alcohol in the same volumes of breath collected at different barometric pressures is the same. This follows from the fact that the partial pressure of a volatile solute in equilibrium with a dilute solution is proportional to its mole fraction in solution (Henry's law). Put another way, the solubility of a gas at a given temperature is proportional to the equilibrium pressure of the gas above the solution. Thus, in this case:

$$p_{\text{alcohol}} = k \cdot c(t)$$

where

- $p$  = partial pressure of the volatile solute above the solution,
- $k$  = a proportionality constant for the temperature concerned,
- $c$  = the concentration of the volatile solute in the solution, and
- $t$  = temperature of the solution.

The following is a simple example of the calculation.

Assume that:

- (1) the only significant modification in a delivered breath specimen is a decline in temperature (actually to about 34.0°C),
- (2) the volume measuring or regulating<sup>2</sup> device operates in such a manner that the breath isolated for analysis is at ambient pressure (or at a pressure difference so small as to be negligible), and
- (3) as a general case<sup>3</sup> the volume of breath collected at 34°C is 50.0 ml, having a partial pressure of alcohol of 0.5 mm Hg (that is,  $p_{\text{alcohol}} = 0.5$ ) and that the molecular volume of alcohol vapor is 22,400 ml at normal temperature and pressure (NTP).

Received for publication 21 March 1973; revised manuscript received 6 Aug. 1973; accepted for publication 7 Aug. 1973.

<sup>1</sup> Professor of forensic medicine and toxicology, Department of Pathology, University of Texas Southwestern Medical School at Dallas, Texas and director, Criminal Investigation Laboratory, Institute of Forensic Sciences, Dallas, Texas.

<sup>2</sup> Measurement of infrared absorbance across a tube of fixed dimensions is an example of employment of a regulated volume. Any defined length of the tube has a fixed, although unmeasured volume.

<sup>3</sup> The general case is used in order to avoid particular, but complicating, features of proprietary instruments. Thus, one which collects a measured volume (52.5 ml) presumed to be at 34°C, raises its temperature about 20°C and subjects slightly less than the total volume to oxidative analysis. Certain operative features eliminate error due to these manipulations.

Then, at sea level, the percent by volume of alcohol in the measured specimen is

$$\frac{0.5}{760} \times 100 = 0.0658 \text{ percent}$$

and the volume of alcohol vapor (at 34°C) is

$$0.000658 \times 50 = 0.0329 \text{ ml}$$

Converting to NTP

$$0.0329 \times \frac{273}{307} = 0.02925$$

whence

$$\begin{aligned} \frac{0.02925 \times 46.05}{22,400} &= 0.0000601 \text{ g} \\ &= 0.0601 \text{ mg in the specimen analyzed}^4 \end{aligned}$$

At a barometric pressure of 500 mm (approximately 9000 ft) the percent by volume of alcohol is

$$\frac{0.5}{500} \times 100 = 0.10 \text{ percent}$$

and the volume of alcohol vapor at 34°C in the measured specimen is

$$0.0010 \times 50 = 0.050 \text{ ml}$$

Correcting to NTP

$$0.05 \times \frac{273}{307} \times \frac{500}{760} = 0.02925 \text{ ml}$$

whence

$$\begin{aligned} \frac{0.02925 \times 46.05}{22,400} &= 0.0000601 \text{ g} \\ &= 0.0601 \text{ mg of alcohol in the} \\ &\quad \text{specimen analyzed} \end{aligned}$$

This independence of barometric pressure also follows from Dalton's Law.

Any procedure which involves collection of a breath specimen at one pressure and measurement or regulation of the volume analyzed at a different pressure will, obviously, require a correction of the result obtained for the barometric pressure difference if the magnitude of the change is significant.

A recent experimental study employing one make of instrument (Breathalyzer<sup>®</sup>) demonstrated its independence of barometric pressure [1]. The reason assigned for this independence was that the subject must lift an 87-g weight in the collecting chamber as he expires, assuring a constant volume for each sample. This is incorrect.

## Reference

- [1] Leonelli, L. P., Pfau, R., and Wick, R. L., Jr., "Altitude Effects on Alveolar Ethanol Analysis," *Aerospace Medicine*, Vol. 40, 1969, pp. 1388-1399.

P.O. Box 35728  
Dallas, Texas 75235

<sup>4</sup> If the sample were deep-lung air the corresponding alcohol concentration in postabsorptive arterial blood with an average hematocrit reading would be 0.252 percent weight by volume.