

DWI

BY EDWARD L. FIANDACH

A Critical Examination Of Breath Testing Assumptions and Techniques

Lately, there has been much discussion in newsgroups, list servers and the media concerning source codes and their logical legal imperative, source code litigation. Simply put, source codes are the computer instructions followed by a computing device in processing information. A review of the source codes employed in the processing of a breath test would be worthwhile to determine whether the device is actually following the parameters set out by the manufacturer. Notwithstanding that such a review has proven difficult, there have been successes.

Several Florida counties have ruled that the defense is entitled to the Intoxilyzer™ source codes, and an older Washington state analysis of DataMaster™ source codes revealed numerous difficulties with the software. Undoubtedly there will be more such challenges, but what seems to be lost in the midst of this litigation is an examination of the premises underlying breath testing generally. This article reviews some of the more salient issues. Note that with the exception of my conclusions dealing with equilibrium and the parameters of the various infrared machines currently in use, much of what follows is not original to me, but draws heavily upon previous research including that of Dr. Michael P. Hlastala,¹ whose writings I strongly recommend.

Breath testing began with a 1952 consensus report by a sub-committee of the American Medical Association's Committee on Tests for Intoxication. At that time, they reported:

Available information indicates that this alveolar air-blood ratio is approximately 1:2100. However, since each method involves different procedures, different empirical factors are involved in the calculation of concentrations of alcohol in the blood in each of the methods.

Of true interest is that 54 years ago there was recognition among this seminal committee that "different empirical factors" are involved in the acquisition and analysis of a breath sample. Unfortunately, given a relative lack of understanding among both bench and bar of the technical aspects of breath testing, this fundamental principle has been lost. Even so, it is not unimportant. In this article, I will discuss the basics of breath testing and the various assumptions made in the design of breath testing equipment. Be forewarned, it is not my goal to cast aspersions upon any particular machine or manufacturer, but merely to set out what may be dispositive differences for examination by those who may not have been otherwise so inclined.

To fully understand a discussion concerning the assumptions made by the various manufacturers of breath testing equipment, we must begin with a brief explanation of the art generally. All breath testing begins with one basic principle — alcohol is water soluble. Therefore, as alcohol is metabolized, it is dispersed throughout all tissues, structures, organs and systems containing water within the human body. Plasma, which is composed of approximately 90 percent water, constitutes 50 percent of the total volume of blood in the human body. Alcohol naturally migrates to this plasma, which becomes the basis through which alcohol is transported to the muscles and the brain. As a brief aside, alcohol is not fat soluble. Therefore females, who have a higher percentage of fat per unit of body weight, will see a greater percentage of alcohol in the blood per unit consumed.

Blood, as we know, is oxygenated by the approximately 3,000,000 alveolar sacs found at the end of respiratory bronchioles in the lungs. Although we tend to speak of "deep lung air," this term is technically incorrect. The oxygen/carbon dioxide exchange, vital for life, occurs at all levels of the lungs at the end of each bronchiole tree. While by no means a scientific explanation, the tissue membranes in these alveolar sacs can be equated to gills in a fish. Carbon dioxide and other pollutants pass outward from



the blood and into the lungs for exhalation, while life-giving oxygen passes from the inhaled breath into the blood. While the second function is critical to life, it is the former which is critical to breath testing. One of the pollutants that is passed out for exhalation is alcohol.

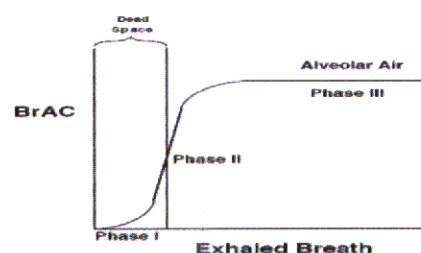
Crucial to the entire concept of breath testing is that there is believed to be a relationship between the quantity of alcohol contained in exhaled breath and the quantity of alcohol contained in the blood. This is commonly known as the "Blood/Breath Partition Ratio," although in trials and lectures I prefer to refer to it as the "Blood/Breath Conversion Factor."² While breath testing equipment manufactured for use within the United States presumes this ratio to be 2,100:1 or 2,100 parts of alcohol in the blood for every part present in exhaled breath, this ratio has been the subject of vigorous debate. Various countries, for instance, have opted for other blood/breath relationships. Great Britain and Holland use 2,300:1, and Austria has chosen 2,000:1. Norway has joined the United States, Canada and Australia, where 2,100:1 is the accepted ratio. Likewise, scientific circles have not been universal in their

acceptance of this relationship. Kurt M. Dubowski and others have found the normal range in test populations to vary from 1,100:1 to 3,000:1. These variances can be profound. As we note in *New York DWI 2d*, a breath test will report a 0.10 percent for a subject who has a true BAC of 0.07 percent if he or she has a partition ratio of 1,500:1. Conversely, a breath test will report 0.10 percent for a subject who has a true BAC of 0.14 percent if he or she has a partition ratio of 3,000:1.³ In a paper presented in part at the Seventh International Conference on Alcohol and Road Safety, A.W. Jones noted that the blood/breath partition ratio varies not only between individuals but *within specific individuals across a one-hour period*. In a study conducted upon 21 males aged 30-55, Jones observed blood/breath partition coefficients ranging between 1,837 and 2,666. More importantly, individual subjects disclosed co-efficient variations ranging from .95 percent to 12.56 percent.⁴

Such variability aside, it is important to emphasize at this point that this presumed relationship is only valid when the source of the exhaled breath is alveolar air in a subject that has fully absorbed all alcohol consumed. Full absorption is a necessary requirement since the breath/blood system must be in equilibrium or stabilized. In the event that the subject is still absorbing, the system will be highly unstable and the ratio between exhaled alcohol and that which is contained in the blood will be much lower. This instability was reflected in a Jones study which identified a rapid rise in total BAC shortly after ingestion. Jones noted that this rise represented absorption of alcohol from the stomach and intestine to the bloodstream and further noted that during this stage, the blood/breath partition ratio tended to be uniformly low, thereby "implying that an estimate of blood alcohol based on breath analysis would be too high during this phase."⁵

Reflecting the foregoing, an essential component of all breath testing is that a state of blood/breath equilibrium exists in the alveolar region located at the terminus of each bronchial tree. As noted by Hlastala,⁶ traditional thinking conceived during the early days of research into the workings of the cardio-pulmonary system was that after breath contained in the "dead space," or that air contained in the bronchial passages leading up to the alveolar region, was exhaled, the alcohol content of alveolar

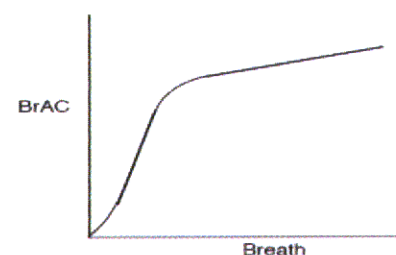
air would remain relatively constant. As set out graphically by Hlastala:



If this "traditional" model was indeed correct, there would be little consternation in the design of any breath testing device. All that would be required would be a mechanical system or computer program that would exhaust that portion of breath exhaled during Hlastala's phases one and two, measure the alcoholic content of the breath exhaled during phase three, and multiply it by the chosen ratio.

Alas and alack, modern research into the inner workings of the lungs tends to invalidate such a simplistic view. As Hlastala points out, the upper airways leading to the alveolar region are lined with mucus membranes (mucosae). These mucosae are vital for life and have, as a critical role, the humidification of air passing into the lungs. As noted above, alcohol is strongly soluble in water. Due to this high solubility and the temperature of inhaled breath, alcohol from the alveolar exchange is deposited in the mucosae during exhalation. This alcohol is subsequently picked up during inhalation and carried to the respiratory bronchioles and ultimately the alveoli. Citing previous research, Hlastala notes that due to the higher vapor pressure of alcohol above blood, a small amount of alcohol is picked up in the alveoli. However, that alcohol is subsequently lost by the time that portion of the breath reaches the 16th or 15th generation of the bronchial tree. Additional alcohol is further lost as the exhaled breath makes its way along the airway to the mouth. Importantly, Hlastala concludes, "all the alcohol exhaled at the mouth comes from the airway surface via bronchial circulation. No alcohol originates from the pulmonary circulation in the alveoli."⁷ Bearing in mind the very active exchange of alcohol that occurs along the airway, Hlastala has shown, and it stands to reason, that the further the breath travels, the greater the quantity of alcohol that will be absorbed.⁸ Far from producing the "traditional" plateau

shown above, Hlastala notes that the representative curve is more like this:



Thus, Hlastala concludes that BrAC⁹ is dependent upon the volume exhaled; a proposition that, as he notes, is in agreement with Jones¹⁰ and others.¹¹

As noted above, equilibrium is essential to the accuracy of breath testing. Early thinking believed that breath represented an acceptable sample for determining blood alcohol content because a state of equilibrium existed between the alcohol in the capillaries of the alveoli and the air space immediately above them. Equilibrium may be understood by visualizing a beaker containing an alcohol/water solution. If the top of the beaker is firmly sealed by means of a tightly drawn rubber sheet, molecules of alcohol will rapidly leave the solution and enter the air space above the liquid. Eventually, these molecules will enter a state where one molecule will transfer from the gas above the liquid into the solution for each molecule that moves from the liquid to the gas. This is a state of equilibrium whereby the ratio of the molecules of alcohol in the gas to those in the solution is fixed. The AMA report cited above recognized that ratio to be 2,100:1 or 2,100 molecules of alcohol in solution for each one in the airspace above the liquid. The difficulty with the concept of equilibrium is that it is difficult to achieve and cannot even be duplicated by a so-called simulator.

In a breath alcohol simulator, the selected figure, generally .10 or .08 percent, is produced by adding a specified quantity of alcohol to distilled water. As noted by Dubowski,¹² a simulator-alcohol concentration of 1.22 mg/mL, or a .122 solution, is required to produce an effluent-alcohol of 100 mg/210 liters by equilibrium with air at 34EC. According to Dubowski:

Although the 1.21 mg/mL alcohol concentration differs by only 1.3 percent from the required 1.226 mg/mL, use of

the former has a significant, unfortunate effect. Breath-alcohol analyzers are commonly calibrated by designating the effluent obtained from air passage through the 1.21 g/liter alcohol solution at 34EC as nominally containing 0.100 g/210 liters (et cetera for other alcohol solution concentrations). The instrument readouts thus over report the actual vapor and breath alcohol concentrations and their assumed blood-alcohol equivalents by the same 1.3 percent. Such overestimation is forensically indefensible, especially at the critical 0.10 percent w/v blood-alcohol concentration, which is a key decision point in jurisdictions with per se driving-under-the-influence-of-alcohol statutes and in borderline decisions in jurisdictions using the 0.10 percent w/v BAC presumption defining the alcohol element of certain traffic offenses.¹³

Moreover, in human subjects, it is physiologically impossible to achieve a true state of equilibrium. To prove this, do the following: take three or four deep breaths. Assuming you were alcohol free, you should still be so. The breathing of plain room air will do nothing whatsoever to raise your blood or breath alcohol content. And therein lies the crux of the problem with human equilibrium. *A living human being can never possess a true state of blood/breath equilibrium as long as he or she continues to breath!* Recall that once a state of equilibrium is achieved, one molecule must leave the gaseous state for every molecule that departs the liquid. In terms of human physiology, one molecule of gaseous ethanol must be imparted to the blood to replace each molecule which enters the breath for ultimate exhalation. Unless the subject is inhaling ethanol, this cannot occur. *Or can it?*

Recall our discussion of the role played by esophageal and bronchial mucosae. According to Hlastala, these mucosae become saturated with alcohol. Thus, it may very well be the alcohol from these mucosae that "completes" the equilibrium loop. If breath testing "seems" to work, if the result appears to "ballpark" the expected BAC, it is probably for this reason. The difficulty, and this is exceedingly important, is that the

alcoholic content of the mucosae does not reflect that of the blood. The quantity of alcohol found in the mucosae is due to a variety of factors, environmental, temporal and physical. There is no physiological linkage between the quantity of alcohol contained in the mucosae and that contained in the blood. As such, a breath test, while some indication of alcoholic consumption, is by no means a reliable indication of a specific blood alcohol content.¹⁴

Even if you reject all of the foregoing as speculation, alcohol breath testing is still not out of the woods. Since its inception, breath testing has demonstrated a continual effort to insure that the sample was "deep lung" in composition. Early wet chemical analytical devices, such as the Stephenson/Smith & Wesson/Dräger Breathalyzer™ 900 and 900A, dealt with volumetric considerations in a fairly straightforward manner. The 900 and 900A employed a piston which would physically trap 52.5 cubic centimeters of the motorist's breath. When the operator, who was instructed to place his/her hand on the small of the subject's back, felt the motorist completing an exhalation, he or she was instructed to flip a switch that enabled a piston to fall, seal off a series of vent holes and send the sample to the ampoule for the analysis. Trapping the last 52.5 cubic centimeters in this fashion was believed to provide a sample of "deep lung" air. With the advent of infrared testing, trapping disappeared. No commercially viable infrared breath testing machine traps a sample. Instead, the devices utilize real-time analysis of telemetry from various devices in an effort to assure that the sample is "deep lung" in composition. In one fashion or another, they monitor the subject's output and simultaneously attempt to determine if it fits within software parameters modeled upon the manufacturer's profile of what an acceptable alveolar sample looks like.

The DataMaster™, for instance, allows the sample to pass uninterrupted through a folded three-segment chamber. Simultaneously, a thermistor in the breath delivery system is monitored for breath induced cooling. A thermistor is a temperature controlled resistor. Alterations in temperature will cause a change in resistance. Cooling is thus measured against time and processed utilizing information contained in the source code to translate the rate of cooling into two distinct calculations — rate of exhalation and total volume of the exhaled breath. When the ther-

mistor in the DataMaster™ detects that the subject is blowing at a 1.5 liters/minute rate, it will begin monitoring the BrAC by means of a beam of infrared light which is passed through the breath. The DataMaster™ will continue to monitor the flow rate and when that flow rate drops below 3 liters/minute, the CPU examines the breath output. If the increase in a two point consecutive average is less than or equal to .001, the CPU will take a .25-second snapshot of the BrAC (which is assumed to be the BAC) and record the result.

The Dräger AlcoTest 7001 mkIII, on the other hand, begins by initially monitoring the temperature of the subject's breath by means of a hot wire anemometer. A hot wire anemometer is different from a thermistor in that it is heated, but it performs the same function as a thermistor since it is the breath induced cooling of the anemometer that is measured. The machine also monitors the pressure of the blow by means of a pressure sensor which is located in the sample hose. While the pressure parameters are unknown, Dräger reports¹⁵ that the flow rate must be .1 liter/second which represents 6 liters/minute. This flow must be main-

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tained for more than three seconds while the BrAC curve remains flat.

The Intoxilyzer 5000, on the other hand, has completely abandoned temperature as a means of flow measurement. Relying solely upon a pressure switch, this unit mandates a minimum time of 4 seconds at a pressure of 4 inches of water.

Clearly there are significant variations between the parameters chosen by the various manufacturers to determine "deep lung" air. Thus, much of the current passion for source codes seems misplaced. While it would be *interesting* to see if the source codes track the reported requirements, a more seminal issue is whether these requirements meet the standards for a valid breath sample which is indicative of blood. For instance, let's examine temperature. Is it legitimate to use a thermistor or a hot wire anemometer to determine the flow/volume of a moisture laden human breath sample at a nominal 34 degrees? Have physical, age and sex differences been adequately accounted for?¹⁶ What is the source of the calculations that are used to determine the result? Are Dräger and National Patent Analytical Systems using the same rates of cooling? If not, why? What are the consequences of utilizing a flow rate of six liters/minute as opposed to three liters/minute? Have any of these flow rates been verified against any medical or scientific benchmarks? And what about time? CMI requires four seconds. Dräger requires three and NPAS has no minimum time requirement at all. Are all of these time-based assumptions valid? More importantly, are *any* of these assumptions valid? Will a longer blow result in a higher reading as is postulated by Hlastala? Have these parameters been tried in different environmental factors such as varying pressures, altitudes or temperatures? Finally, are clear variations in the manner in which breath testing devices compute results serving to deny criminal defendants their constitutional right to Equal Protection?

Before we seek to determine whether the instructions are being followed, we should first attempt to determine the propriety of those instructions.

While these issues seem complex, resolution is not. What I suggest is a program to retrieve breath testing data and sort the results by machine. If our concerns are specious, there should be no statistical variation in the total BrAC curve irrespective of the machine employed. If they vary, then attention

should be paid to the software parameters utilized by the various machines in an effort to determine which, if any, are indeed valid. Finally, a comparison of the breath test data sorted by machine and amplified by a statistical Monte Carlo program such as that utilized by Feldman and Gutmann¹⁷ with blood test data similarly correlated should prove dispositive of these contentions. If we are correct, one would expect to see variations outside of expected statistical error. If incorrect, the correlation should prove statistically insignificant.

Notes

1. See <http://www.mphlastala.com>.
2. My reason for doing so is manifest. A ratio is seen as a relationship which is fixed. A "conversion factor" is subject to change which indeed this factor is.
3. Fiandach, Edward L., *New York DWI 2d ed.*, WestGroup, 1996 and 2005, at 897 quoting, Fitzgerald, Edward F., Hume David N., *Intoxication Test Evidence: Criminal and Civil*, Clark Boardman Callaghan, § 4:15, at 134.
4. A.W. Jones, *Variability of the Blood: Breath Alcohol Ratio in Vivo*, J. STUD. ALC., Vol. 39, No. 11, 1973, at 1931.
5. *Id.* at 1935.
6. Hlastala, Michael P., Ph.D., *The Alcohol Breath Test, a Paradigm Shift*, available at www.mphlastala.com/abt.pdf
7. *Id.* at 9.
8. As further noted by Hlastala, this accounts for the large variation that frequently arises when multiple tests are administered on the same subject.
9. Breath Alcohol Content.
10. Jones, A.W., *Qualitative Measurements and the Temperature of Breath During a Prolonged Exhalation*, ACTA. PHYSIOL. SCAND. 114: 407-412, at 1982.
11. Ohlsson, J.D., Ralph, M., Mandelkorn, A., Babb and M. Hlastala, *Accurate Measurement of Blood Alcohol Concentration with Isothermal Rebreathing*, J. STUD. ALC., 51: 6-13, at 1990.
12. Dubowski, K., *Breath Alcohol Simulators: Scientific Basis and Actual Performance*, J. ANAL. TOXICOL. 1979, Vol 3, at 177-182.
13. *Id.* at 181.
14. While obvious differences exist, the situation may be equated to attempting to determine blood alcohol content from a urine sample that was obtained without the necessary voiding.
15. 86 DRÄGER REVIEW, October 2000. It should be pointed out that different selection criteria are reported by various sources for this machine. The Web site for Toxexperts (www.toxexpert.com) for in-

stance, reports a minimum flow rate of 2.5 liters/minute, a minimum breath volume of 1.5 liters and a minimum blow duration of 4.5 seconds. While only speculation, the difference may be due to "regionalization" of the various models. In preparing this article, I chose to rely upon data furnished directly by Dräger.

16. Only Dräger seems to recognize that such differences exist. Such recognition notwithstanding, it seems to avoid the possible ramifications with a certain circuitry of logic:

"The required minimum volume of breath depends on the age and sex of the test subject and is considerably greater than the volume of the gas conduction system. The minimum values have been worked out and laid down during the course of extensive studies to measure that only deep lung air is analyzed regardless of age and sex."

86 DRÄGER REVIEW, October 2000.

Again, questions can be raised. Who did these "extensive studies" and, if done by Dräger, isn't it fair to assume that this corporate entity had a certain financial interest in the outcome?

17. J. Feldman & S. Gutmann, *A Study of DUI Law Enforcement Practice Based on EBT Data From 5 Precincts in Massachusetts and California*, 29 JURIMETRICS J. 221-238 (1989). ■

About the Author

Edward L. Fiandach is a criminal defense



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