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Fundamental Principles of Breath Testing: An Imperfect Means to a Legitimate End

On September 10, 1897, a London cabdriver named George Smith became the first person in recorded history to be arrested for driving while under the influence of alcohol ("DUI"). It was obvious to the bobbies that he was intoxicated. Also obvious was that his being intoxicated affected his ability to drive a car. Mr. Smith crashed his taxi cab into a building. Mr. Smith pled guilty and was sentenced to pay 25 schillings.[1] The purpose of his prosecution was as valid as it was clear: to keep the streets safe from drivers whose abilities to operate a motor vehicle were impaired by alcohol.

What if Mr. Smith was not such a cooperative defendant? After all, Mr. Smith made it easy for the prosecution: he admitted to drinking, and his driving was clearly impaired. Not all DUI defendants are as easy to convict. In the early days of impaired driving investigations, prosecutors lacked any scientific way to prove someone was too intoxicated to drive. Criminal cases were thus based on what became known as common law driving while impaired by alcohol. The definition of what amounted to impaired driving varied from state to state—and still does. Most states' definitions of impaired driving involve some form of proof that a defendant drove a vehicle while the alcohol he consumed impaired the abilities which are needed to operate a motor vehicle as a reasonable and prudent driver.

On December 5, 1933, the ratification of the 21st Amendment brought the end to prohibition and joy to many Americans thirsty for alcohol. It gave birth to a vibrant industry eager to quench the thirst of Americans. Drunk driving became a fast-growing problem. The law enforcement community

[1] History of Drunk Driving, http://www.DrunkDrivingPrevention.com (last visited August 16, 2018).

was challenged to search for a more objective and easier method to determine a driver's level of impairment. Police needed an easier way to determine if someone was intoxicated and prosecutors needed an easier way to convict drunk drivers; what evolved was the use of blood alcohol levels as a litmus test.

It is an axiom of forensic science that the quantification of the amount of alcohol in a person's blood can be relevant to determining what impact the consumption of alcohol has had on that person's cognitive ability to operate a motor vehicle.[2] This is because of the way alcohol is diffused into the blood and carried through the circulatory system including the brain. After a person consumes alcohol, the alcohol enters the stomach where absorption begins. After digestion, most alcohol absorption into the body happens in the small intestine through a form of diffusion. The alcohol enters the capillaries and is carried into the veins where it can then be distributed throughout the entire circulatory system.[3] Once the ethyl alcohol reaches the brain it can impact cognitive functioning and a person's ability to drive.

While analysis of a sample of blood can be forensically reliable for measuring a driver's intoxication levels, it has its disadvantages. The sample collection is invasive and drawing the sample can be difficult for law enforcement officers to administer. The analytical process is costly and time consuming, not affording law enforcement officers the ability to make determinations in the field. Its usefulness is further complicated because its processes require additional laboratory analysis. So forensic scientists like Dr. Emil Bogen started to look for other ways to measure a person's blood alcohol concentration. Scientists looked for faster and simpler ways. But faster and simpler are not necessarily more reliable.

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[2] Center for Disease Control and Prevention, *Frequently Asked Questions,* https://www.cdc.gov/alcohol/faqs.htm (last visited August 26, 2018).

[3] James C. Garriott, *Garriott's Medicolegal Aspects of Alcohol* (5th Ed. 2008).

In 1927, Dr. Emil Bogen demonstrated that breath samples from a subject containing alcohol could give an indication of the subject's corresponding blood alcohol concentration levels.[4] This led to the development of devices which could analyze the amount of alcohol in a person's breath to determine the amount of alcohol in that person's blood. In 1938, the first breath testing device was put into use by law enforcement officers in the field when investigating drunk driving. This invention, called a "drunkometer," was the creation of Professor Rolla Harger of Indiana University. Drivers suspected of being drunk were asked to breathe into a rubber balloon, which was attached to a tube of purple solution of potassium permanganate in sulphuric acid. This is likely the reason for the term "chemical test" which is often used to describe a breath test. If there was alcohol in someone's breath, the chemical solution changed color; the darker it got, the more alcohol the motorist had in his system. From the shade of the liquid, law enforcement officers could estimate the alcohol level in a person's bloodstream.[5]

The scientific principle that is the foundation for testing a subject's breath to measure the alcohol concentration in that same subject's blood is Henry's Law. Henry's Law was formulated by William Henry in 1803, and provides that "at a constant temperature, the amount of a given gas that dissolves in a given type and volume of liquid is directly proportional to the partial pressure of that gas in equilibrium with that liquid."[6] A simpler definition perhaps is that the amount of a volatile substance in a liquid is directly proportional to the amount of that same volatile substance in the gas above that liquid, in a closed environment, so long as that liquid and gas are maintained at a constant temperature and a constant pressure.[7] An example of Henry's Law at work is in the ordinary bottle of soda. The contents of the bottle are kept in a closed environment at a constant pressure. Because of this pressure,

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[4] History of Drunk Driving, http://www.DrunkDrivingPrevention.com. (last visited August 16, 2018).
[5] Breathalyzers in history, https://www.drinkdriving.org/drink_driving_information_breathalysers_early.php (last visited August 26, 2018).
[G] Garriott's Medicolegal Aspects of Alcohol, *supra* at 260.
[7] *Id.*

the carbon dioxide (the gas that makes the beverage carbonated) is soluble in the liquid you enjoy drinking because of the bubbles. When you open the bottle, you release the pressure and the carbon dioxide becomes less soluble and is released into the environment. Over time, the carbon dioxide would release completely, and you would be left with flat soda.

Applying Henry's Law, since ethyl alcohol is a volatile substance, the amount of ethyl alcohol in a liquid solution in a closed environment, kept at a constant temperature, will reach a point of equilibrium where there will be a fixed correlation between the amount of ethyl alcohol in that liquid and the amount of ethyl alcohol in the head space gas above that liquid. An example of Henry's Law at work is a wet bath simulator, often used as a reference standard in breath testing. The simulator contains a known concentration of ethyl alcohol, obtained from a traceable source. That solution is kept in a sealed environment and at a constant temperature (34-Degrees Celsius – which will be discussed later in more detail). Since ethyl alcohol is volatile, it will exist both in the liquid and the gas in the sealed container. By measuring the ethyl alcohol in the gas above the liquid, a breath testing device can measure the amount of that same ethyl alcohol found in the liquid.

The theory behind breath testing for alcohol is that by analyzing the amount of ethyl alcohol found in the breath (gas) we can quantify the amount of ethyl alcohol in the blood (liquid). To make that quantification the breath testing device must know the proportional relationship between the amount of ethyl alcohol in blood as compared to breath once equilibrium is obtained. This relationship between the concentration of ethyl alcohol found in the blood compared to the breath is referred to as the partition ratio, which for breath testing is assumed to be 2100:1 for all individuals, but it varies from person to person and is not constant. This theory as applied to breath testing has its faults which will be discussed below.

The ability to measure breath alcohol concentration quickly and inexpensively helped usher in "per se" statutes, which made it a crime to drive with levels of ethanol in the blood or breath exceeding statutory limits. These "per se" statutes became exactly the tool prosecutors looked for—a tool to make getting convictions easier. The question of whether a person's physical and mental ability to operate a car is substantially impaired is far more amorphous, and harder to prove than whether a person has a breath or blood alcohol concentration above a proscribed limit.

The need for simplicity in prosecutions has caused the casting of too wide a net. The scientific premises on which breath testing for blood alcohol quantification is based have been over-extended and taken us far from the original purposes of drunk driving laws which were to make our streets safe from drivers whose ability to operate a motor vehicle is impaired by alcohol.

The reliance on quantifying blood alcohol concentration by analyzing a person's breath sample has been generally accepted in our courts, but that acceptance has not been shared by many members of the scientific community including forensic toxicologists. The Society of Forensic Toxicologists (SOFT) is composed of practicing forensic toxicologists for promoting and developing forensic toxicology.[8] SOFT sponsors technical publications to improve the forensic toxicologists' skills and knowledge. One such publication is the Forensic Toxicology Laboratory Guidelines. Although the guidelines review methodology of blood and urine testing for alcohol, SOFT did not consider breath testing as a method to quantify blood alcohol levels.[9] Why do you suppose that decision was made? Perhaps it was not found to be reliable enough for forensic measurements. I challenge you to find any accredited lab that uses the type of breath testing devices now used by law enforcement officers in their precincts. Regardless of whether the law enforcement community elects to use a breath-testing device, it still must do so in a manner that makes the test forensically reliable.

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[8] Society of Forensic Toxicologists, Inc., http://www.soft-tox.org/ (last visited August 26, 2008).
[9] Forensic Toxicology Laboratory Guidelines, 6.4.2 (2006), Society of Forensic Toxicologists, http://www.soft-tox.org/files/Guidelines_2006_Final.pdf.

The reliability of any forensic test, such as a breath test, is dependent on, among other things, the manner the device is calibrated. The term calibration is often confused with certification. A device is certified when it is presented with a known analyte[10] and is then used to quantify that analyte; if the amount of the analyte is within a degree of uncertainty, also called tolerance, then the device is considered certified.[11] A simulator is a device used to introduce a known amount of ethyl alcohol from a traceable source into a breath testing machine. If the machine reports the quantification of the ethyl alcohol to be the same as the known concentration in the simulator solution, plus or minus the margin of tolerance, then the machine is certified. The amount of tolerance allowed will vary from state to state and may be wider than the amount of tolerance allowed by the manufacturer of the device.

A calibration is completely different. A calibration is the process of presenting known quantities of an analyte into the machine and then adjusting the machine so that it can properly quantify that same analyte in future tests. A calibration teaches a machine how to respond for future uses.[12] Often police departments only employ single point certification and then call it a calibration. No matter what you call a duck, it is still a duck. The problem with such an operating procedure is that a calibration requires at least three points of measurement to create linearity across a spectrum of possible results.[13]. The use of a single point certification will only ensure a measuring device can correctly identify and quantify an analyte at a fixed point, e.g.,.10 blood alcohol concentration. Predicting reliability of a measuring device over a range of possible responses would require calibration at multiple points, thus allowing for the graphing of a straight line. The lowest and the highest quantifications of the three samples establishes the range at which the device has been calibrated to quantify results.

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[10] An analyte is a substance whose chemical constituents are being identified and measured, e.g. ethyl alcohol.
[11] Thomas E. Workman, Jr., *The Science Behind Breath Testing for Ethanol,7* U MASS L. REV. 136 (2014).
[12] *Id.*
[13] Forensic Toxicology Laboratory Guidelines, *supra*, at 6.4.2.

Another concern about the reliability of breath testing is associated with the failure to report the uncertainty of its results. Although breath tests can reliably detect the presence of alcohol in the human body, it is less clear to what degree of certainty breath testing can measure the amount of alcohol in the blood. After all, if technicians analyzing blood specimens in a laboratory environment using gas chromatography are required to report their results to a margin of uncertainty, how can police officers using breath testing devices report their results to a specific number without reporting its margin of uncertainty? Uncertainty calculations are rarely if ever done in the field of breath testing.

There are many reasons for margins of uncertainty in breath testing. One of them is fluctuations in body temperature. The requirements of Henry's Law—a closed system with constant pressure and constant temperature—simply do not apply in the lungs. Fluctuations in body temperature can have a severe impact on the reported blood alcohol concentration. For every 1-degree Celsius increase in body temperature above that assumed by the device, there will be a corresponding drop of 6.5% in blood to breath partition ratio, resulting in an increase in reported blood alcohol concentrations of 6.5%.[14] Now consider that the average body temperature for humans is 37-degrees and the breath testing devices are certified with a simulator solution maintained at 34-degrees Celsius. This alone can falsely elevate reported blood alcohol concentrations by over 20 percent.[15]

Another factor impacting variability in breath testing results is that the blood-to-breath partition ratio is not one size fits all. It varies from person to person. There are variables in blood-to-breath partition ratios and the breath testing device assumes a ratio of 2100:1. If the true partition ratio of a blood sample is different from the assumed sample an error will occur in the measurement.[16] The lower the true blood-to-breath ratio, the more the reported level will be falsely elevated. Studies have

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[14] Michael P. Hlastala, Physiological Laws of Alcohol Breath Testing, *available at* http://www.duistopped.us/physiology-bac-media/11.pdf.

[15] *Id.*
[16] *Id.*

shown that this can result in over-estimating blood alcohol concentrations by 20-25% in 20% of the population.[17] To give you some idea of how much a lower blood-to-breath ratio can have on a subject's test, take the example of a person with an assumed blood to breath ratio of 2100:1 and a result of .10 blood alcohol concentration. If that same person had a true partition ratio of 900:1, the person's true blood alcohol concentration would be .04.

To counter these attacks, some states have amended per se statutes to penalize driving with breath alcohol levels instead of blood. This has taken us far from the original goals of drunk driving laws, which were to prevent drivers from getting behind the wheel while impaired. That is because breath-alcohol concentration may not always reflect the concentration of alcohol in blood, and in turn may not correlate to impairment, since it is only when alcohol reaches the brain that the effects associated with intoxication become observable.

None of this discussion of the fundamentals of breath testing is meant to imply that such testing is presumptively unreliable. Quite the opposite is true. Many breath testing devices have been reviewed and placed on the United States Department of Transportation's Federal Conforming Products List for Evidential Breath Testing Devices.[18] Breath testing devices are admitted into evidence in courts throughout the nation. But if breath testing is to be used, it is critical that police departments conduct their breath testing in compliance with a quality assurance program to safeguard the testing process and validate its results. This quality assurance program must consider, among other things: the test subject; the analysis process; the manner a test result is reported and recorded; and inspection and maintenance of the devices used for breath testing.[19] Particularly important to the quality assurance program are a

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[17] Jan Semenoff, *Blood to Breath Ratios in Alcohol Testing*, 1 Counter-Point Journal (2016). *See also* T.A.A Alobaidi, D.W. Hill, and J.P. Payne, *Significance of Variation in Blood-Breath Partition Coefficient of Alcohol*, Brit. Med. J. (1976).

[18] Highway Safety Programs; Conforming Products List of Evidential Breath Alcohol Measurement Devices, 82 Fed. Reg. 50940 (November 2, 2017), *available at* https://www.gpo.gov/fdsys/pkg/FR-2017-11-02/pdf/2017-23869.pdf

[19] Kurt Dubowski, *Quality assurance in breath-alcohol analysis, 18* J. of Analytical Toxicology 306 (1994).

pretest deprivation-observation period of at least 15 minutes and an analysis of at least duplicate breath specimens. Despite this, in many states there is still only one breath sample being tested and the quality of the pre-test deprivation-observation is low. Even the way the result is recorded, i.e., without a reported margin of uncertainty, takes the testing beyond the scientific foundation on which it is built. This is especially important considering the tremendous impact even a .01 difference in blood alcohol concentration can make. It not only can affect whether charges will be brought, but also what level charges and whether a certain plea bargain will be offered to a defendant.

These and other scientific premises on which breath testing for blood alcohol quantification is based have been over-extended, and it is important for stake holders in the field of breath testing, such as attorneys and judges, to be mindful that there is some level of uncertainty in the measurement; that the scientific principles upon which breath testing is based call for a quality assurance process that must be implemented and followed; and that interested parties understand that breath testing is nothing more than an imperfect means to a legitimate end.