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The Untestable Drunk Driving Test

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EXECUTIVE SUMMARY

The intersection of law and science has a long and tortuous history, but a new chapter is being written in New Jersey with the state's use of the Alcotest 7110 MK III-C for prosecuting drunk driving traffic offenses. As the name implies, this is a device which purports to test levels of intoxication by measuring breath alcohol levels in order to determine blood alcohol concentration. The Alcotest is a proprietary device purchased by the State of New Jersey for use by law enforcement under a contract with the manufacturer that prohibits the State from subjecting the device to "reverse engineering" testing. Although the Alcotest was approved for use by the New Jersey Supreme Court after a proceeding that explored its reliability, serious scientific and legal questions remain, largely because of the manufacturer's refusal to sell a device for independent testing or permit the State to provide its devices for such assessment. Given this limitation, any conclusions about the Alcotest are necessarily tentative. Nevertheless, as detailed in this Report, there are serious reasons to doubt the accuracy and reliability of the test, especially the manufacturer's claims of the superiority of its product because, unlike other devices, the Alcotest employs two independent measures of breath alcohol. In reality, the two measures are highly interdependent. In addition, there are other reasons to question the validity of the test as an accurate measure of intoxication.

INTRODUCTION

The dangers of drunk driving have been well known since before the invention of the automobile. As early as the 1800's, railroads enjoined their employees from drinking while on duty.¹ With the advent of the automobile and its proliferation, driving while under the influence (abbreviated DUI or DWI, variously) has become a deadly problem everywhere.² In the United States, over 1.46 million drivers, or 1 out of every 139 licensed drivers, were arrested in 2006 for driving under the influence of alcohol or narcotics.³ If an arrest results in a trial, then the state must necessarily produce evidence "beyond a reasonable doubt" that the suspect was intoxicated in order to prove its case, and so what is needed is an easy, reliable, and inarguable means of proving intoxication.

So how does a state prove the fact and degree of intoxication?

When DUI laws first were enacted, producing evidence of intoxication was problematic. If no one witnessed the suspect drinking, evidence came primarily in the form of the arresting officer's testimony about the suspect's appearance and condition. Such evidence carried a lot of weight, but was necessarily subjective and thus more susceptible to challenge. Police departments developed field sobriety tests (FSTs) as an early attempt to convert these subjective perceptions into objective evidence, but the accuracy and validity of these ad hoc procedures

¹ The earliest such prohibition appears to be the 1936 prohibition by the New York Central Railroad. See See Gary W. Kunsman, "Human Performance Toxicology," in Principles of Forensic Toxicology (ed. Barry Levine, 2nd edition), pg. 16.

² According to the National Highway Traffic Safety Administration, about 13,500 deaths each year are attributable to drunken driving, accounting for almost one-third of all traffic fatalities. Dept of Transportation (US), National Highway Traffic Safety Administration (NHTSA). Traffic Safety Facts 2006: Alcohol-Impaired Driving. Washington (DC): NHTSA; 2008.

³ <http://www.madd.org/Victim-Services/Victim-Services/Statistics.aspx>.

never rose to the level of science.⁴ (The National Highway Traffic Safety Administration has recently developed improved, “standardized” versions that appear to have more predictive power, but these are only intended to establish probable cause for arrest,⁵ and are still dogged with problems of subjectivity.⁶)

The very first objective, scientific means to prove degree of intoxication was based on blood alcohol concentration (BAC). Blood alcohol concentration provides a concrete, scientifically obtained measure that repeatedly has been shown to correlate strongly with increased physical impairment and increased likelihood of being involved in a motor vehicle accident.⁷ In fact, elevated BAC levels quickly became synonymous with intoxication. The first DUI laws were passed in Indiana and Maine in 1939; in both states BAC above 0.15 grams of alcohol per deciliter of blood (0.15 g/dL), was considered presumptive evidence of guilt.⁸ In 1962 the U.S. Uniform Vehicle Code was amended to lower that threshold to 0.10 g/dL, and today almost all states adhere to the even lower threshold of 0.08 g/dL.⁹

Several possible methods are available to determine BAC. The obvious one—administration of a blood test—must be conducted by trained medical professionals and are thus difficult to administer in the field.¹⁰ Urinalysis also provides a way to measure BAC, but urine collection presents its own difficulties and again proves problematic to implement in the field.

⁴ See, e.g., Cole and Nowaczyk, "Field Sobriety Tests: Are they Designed for Failure?" 79 *Perceptual and Motor Skills Journal* 99-104 (1994), in which 46% of the subjects who had no alcohol in their system were judged by officers to be too drunk to drive.

⁵ "Development of a Standardized Field Sobriety Test Training Management System," NHTSA report, Appendix A. Available at <http://www.nhtsa.dot.gov/people/injury/alcohol/sfst/contents.htm>.

⁶ Steven J. Rubenzer, "The Standardized Field Sobriety Tests: A Review of Scientific and Legal Issues," 32 *Law and Human Behavior* 293-313 (2007).

⁷ Kunsman, pgs. 15-29, describes a number of these studies.

⁸ *Ibid.* pg. 17.

⁹ *Ibid.* pg. 18. The 0.08 g/dL threshold is one of the highest in the world. See "Blood Alcohol Concentration Limits Worldwide," a report from the International Center for Alcohol Policies, available at http://www.icap.org/portals/0/download/all_pdfs/icap_reports_english/report11.pdf.

¹⁰ Some police officers, however, do receive training to take blood tests while in the field.

Another inconvenience of both blood tests and urinalysis is that the collection of samples and the determination of BAC are separate processes; the samples obtained from the arrested party produce BAC measures only at a later time and in a laboratory setting. An ideal test would be one which an officer could administer easily and conveniently, and one in which the determination of BAC could occur during or soon after the test itself.

In the 1930s, R. N. Harger developed the Drunkometer, the first machine capable of measuring the amount of alcohol present in a person's exhaled breath, or breath alcohol concentration (BrAC). Subsequently Robert Borckenstein, a colleague of Harger's, developed the Breathalyzer, a portable and easier-to-use version of the earlier machine. There is a fairly direct relationship between a person's BrAC level and BAC level, although that relationship varies according to a host of factors.¹¹ In the United States, the average human BrAC/BAC ratio is used as a proxy for a person's individual BrAC/BAC ratio. The accepted average ratio in the United States is 1:2100. (Other countries use different average figures, for example 1:2300 is used in Great Britain and 1:2000 in Austria.¹²)

In its initial incarnation the Breathalyzer also had a strong subjective element; the officer working the machine was required to judge how dark a particular color was in order to assign a BrAC level.¹³ The Breathalyzer inventor himself intended that the device serve only to support other primary evidence, stating, "When the Breathalyzer was developed, the notion was that breath tests were to be used as corroborative evidence. I have a great deal of difficulty in going along with the idea that we hang our hats on the measure of alcohol in the blood when we don't

¹¹ Some of the factors at play are detailed in Section Three of this report.

¹² A.W. Jones, "Physiological Aspects of Breath-Alcohol Measurements," 6 Alcohol Drugs Driving 1-25 (1990).

¹³ Some defense attorneys called the Breathalyzer 'Dial-a-Drunk' because "[t]he cop can give you any reading he wants by simply turning a balance wheel." Defense attorney Francis Moore, quoted in the article "Drunken Driving Statutes Criticized," by Jay Romano, NY Times, March 11, 1990.

have any measure of behavior.”¹⁴ Nonetheless, the Breathalyzer became the “ideal” test in that police officers could, for the first time, assign a measure of intoxication to a suspect on the spot. Breathalyzer evidence quickly became the centerpiece of almost every DUI case, and it is no exaggeration to say that the Breathalyzer and its descendants completely revolutionized the prosecution of DUI offenses.

One of the newest breath alcohol analyzers is the Alcotest 7110 MK III-C, made by Draeger AG & Co. The Alcotest is the subject of this report. New Jersey has recently adopted the Alcotest as the breath alcohol analysis device of choice in the state. The Alcotest is designed to completely remove all subjectivity on the part of the officer from the determination of blood alcohol concentration. However, the Alcotest machine and the process by which it has been adopted raise the following novel issues:

- In New Jersey, the Alcotest device has been adopted to the exclusion of all other devices. The Alcotest is now the only breath alcohol analyzer of record in the state.
- The Alcotest device is now ‘immunized’ from challenge and from outside testing, and doubly so:
 - a. By New Jersey’s contract with Draeger, which allows Draeger to prohibit any entity other than the state from purchasing the Alcotest, and
 - b. By the decision in *State v. Chun*, which acknowledges Draeger’s intellectual property rights to the source code of the Alcotest, thus preventing any outside entity from determining how the machine works.
- Measurement devices like the Alcotest are inherently inexact, not because of oversights or poor design but because any measurement carries with it measurement errors. Sources of error for previous machines were reasonably well investigated, documented, and understood. The Alcotest, while new and theoretically better than previous designs, is also subject to measurement error, but because of the Alcotest’s immunity to challenge, those sources of error are currently not subject to investigation by scientists, let alone litigants.

¹⁴ *Id.*

The last point—that a consequential and relatively ubiquitous scientific instrument is unavailable for scientific purposes, under any circumstances—is more than a theoretical issue.

We conclude this introduction by detailing the recent efforts of one analytical chemist to purchase an Alcotest for his university laboratory. Dr. Nicholas Snow was formerly Chair of the Department of Chemistry and Biochemistry and is currently the Director of the Center for Academic Industry Partnership at Seton Hall University. Dr. Snow is a nationally and internationally recognized analytical chemist, and has published extensively in analytical chemistry, separation science, and the analysis of drugs and volatile compounds from a variety of materials. In the summer of 2008, Dr. Snow contacted Draeger about purchasing the Alcotest machine for his university laboratory. Dr. Snow was clear that his interest in obtaining information about the Alcotest was purely academic. He informed his contact at Alcotest that he wanted to become properly trained in its operation to help attorneys and the public better understand how breath alcohol analysis works and how it relates to blood alcohol concentrations.

After multiple inquiries by e-mail and phone, Dr. Snow was finally referred to Hansueli Ryser, one of the company's vice presidents, based in Texas. Mr Ryser's initial response to Dr. Snow's request was the following:

As a matter of corporate policy, Draeger Safety Diagnostics, Inc. does not supply instruments, technical information or any other written materials pertaining to such instruments to the general public. Consequently, we are unable to comply with your request.

Dr. Snow followed up on Mr. Ryser's initial rejection. Part of their e-mail exchange appears below. Dr. Snow's comments appear first, and Ryser's replies follow in italics.

S: Thank you for trading emails with me regarding the Alcotest instrument. As I understand, we would need to obtain approval from the State of New Jersey in order to purchase a unit.

R: *No, it is Draeger's decision and Draeger's policy only.*

S: I am still hoping that you would be willing to advise me on whom (perhaps someone in the Attorney General's office) we might approach to obtain the approval.

R: *This would not change anything.*

The hallmark of the scientific process is testing and peer review. As matters now stand, it is impossible to test and review the Alcotest in the courts, and Dr. Snow's experiences show that it is further exempted from testing and review in the scientific community.

This report investigates the process by which the Alcotest was adopted; the extent to which it is immune from testing; the reason that such immunization is dangerous in light of the science of breathalyzers in general and the Alcotest in particular; and, finally, the legal consequences of admission of evidence that cannot be tested either in general or in this particular case. Because science lies at the core of the legal issues surrounding the use of the Alcotest, Part Two of this report describes the science behind blood alcohol tests in general and the Alcotest in particular. Part Three considers the circumstances and the Special Master's decision of *State v. Chun*. Finally, the report's conclusion addresses the legal consequences of the aforementioned testing prohibitions upon the use of the device in litigation.

PART II: BLOOD ALCOHOL TESTING

The use of breath alcohol concentration (BrAC) to estimate blood alcohol concentration (BAC) is based on Henry's Law, which states that, at equilibrium, the concentration of a volatile substance dissolved in a liquid (in this case ethanol in blood) is directly proportional to the concentration of the volatile substance in the air (ethanol in the breath) above the liquid.^{15 16 17} In other words, the concentration of alcohol in the blood produces a corresponding concentration of alcohol in the air in an individual's lungs.

The rate at which alcohol will partition from the blood into the breath depends on both the concentration of alcohol in the blood and the ambient temperature.¹⁸ The higher the temperature, the more alcohol will partition from the blood into the breath.¹⁹ Theoretically, when temperature and concentration of alcohol are constant, a state of equilibrium will result in which the amounts of alcohol in air and liquid will be static.²⁰

The ratio between BAC and BrAC, sometimes referred to as the "blood-breath ratio" (BBR), describes the relationship between blood ethanol concentration and ethanol concentration in breath; $BBR = BAC/BrAC$.²¹ This ratio is used to determine the BAC following breath alcohol testing and is generally assumed to be 2100:1.²² There is, however, significant variability in values for the BBR,²³ with values between 1900 and 2400:1 being reported.²⁴ Partition ratios may vary between individuals, and the partition ratio for a given individual may

¹⁵ See [State v. Downie, 117 N.J. 450, 459 \(N.J. 1990\)](#).

¹⁶ See *Id.*

¹⁷ See Introductory University Chemistry at <http://dwb4.unl.edu/Chem/CHEM869J/CHEM869JLinks/www.chem.ualberta.ca/courses/plambeck/p101/p01182.htm> (updated November 3, 1995). [(hereinafter "IUC").

¹⁸ See *Downie*, 117 N.J. at 45

¹⁹ See *Id.*

²⁰ See *Id.*

²¹ See Michael P. Hlastala. The alcohol breath test - a review. *J Appl Physiol* 1998;84:401-408.

²² See *Id.*

²³ See *Id.*

²⁴ See Melethil SK. Breath tests for blood alcohol determination: Partition ratio at http://www.forensic-evidence.com/site/Biol_Evid/Breath_Tests.html (last visited July 19, 2009).

vary from time to time, as both environmental and genetic factors influence the time course of ethanol in the human body and may impact the rate of equilibration.^{25 26}

The assumptions behind using breath alcohol testing to determine BAC are: (1) that the amount of alcohol present in the sample provided for the machine represents some equilibrium between the amount of alcohol in the expired breath sample and that in the blood;²⁷ (2) the equilibrium is theoretically present in “deep lung” or alveolar air; and (3) that at the end of a complete expiration, alveolar air is what is being sampled by the machine.²⁸

A. The Human Respiratory System

Before one can really understand both the assumptions behind this testing technique and the postulated problems with those assumptions, one must understand at least the basic anatomy of the human respiratory system. The human respiratory system can be divided into upper and lower portions,²⁹ both of which influence the results of breath alcohol testing. The upper respiratory system is comprised of the nose and mouth and the throat,³⁰ while the lower respiratory tract is comprised of the trachea (windpipe), bronchi (branches of the windpipe) and lungs.³¹

The lungs are comprised primarily of air-filled sacs called alveoli.³² It is only within the alveoli that gas exchange between the inspired air and the blood takes place.³³ The alveoli are

²⁵ See *Downie*, 117 N.J. at 460

²⁶ See [Norberg A](#), [Jones AW](#), [Hahn RG](#), [Gabrielsson JL](#). Role of variability in explaining ethanol pharmacokinetics: research and forensic applications. [Clin Pharmacokinet](#). 2003;42(1):1-31.

²⁷ See Hlastala MP. The alcohol breath test – a paradigm shift at <http://www.mphlastala.com/issues.htm> (last updated 1/11/09) [hereinafter “Paradigm Shift”].

²⁸ See Paradigm Shift.

²⁹ See Paradigm Shift.

³⁰ See *Id.*

³¹ See *Id.*

³² See *Id.*

³³ See *Id.* at 2 (alveoli appear at about the 17th generation airways).

located deep within the lungs and can only be reached after many branching of the bronchi.³⁴ It is for precisely this reason that the deep lung air, obtained at the end of a complete exhalation is sought in breath alcohol testing to presumably provide breath that has an ethanol content in equilibrium with BAC.³⁵ Controversy exists as to whether the concentration of ethanol in the breath actually measured by the device represents alveolar concentration.³⁶

Historically, gas exchange was believed to occur only at the arteriole-alveolar boundary.³⁷ Currently, breath alcohol testing is based on the belief that alcohol concentration in alveolar or “deep lung” air is representative of arterial blood alcohol concentration.³⁸ This is based on assuming: (1) the relationship between the blood alcohol concentration and breath alcohol concentration can be described by the blood-breath ratio or partition coefficient; (2) the alcohol concentration in alveolar air remains unchanged as the air transits through the respiratory tree; and (3) once the anatomic dead space (the area of the respiratory tree where no gas exchange between blood and air takes place) of the trachea and upper airways is cleared, alcohol concentration in the expired air is constant.³⁹

However, as a person breathes, the air taken in passes through the nose and/or mouth and into the trachea or windpipe, the surface of which is covered with a watery mucous.⁴⁰ As the inspired air comes into contact with the mucosal surface, gas exchange between the surface of the bronchioles and the inspired air may take place.⁴¹ This exchange, though governed by the same laws and analyzed with the same equations as the gas exchange that takes place between

³⁴ See Paradigm Shift.

³⁵ See *Id.*

³⁶ See Paradigm Shift at 9.

³⁷ See *Id.*

³⁸ See Paradigm Shift.

³⁹ See *Id.*

⁴⁰ See *Id.* at 6.

⁴¹ See Paradigm Shift.

inspired air and blood, occurs between the inspired air and a substance other than blood, namely the watery mucous that lines the respiratory tract.⁴²

Like the equilibrium between blood and the air above it for ethanol, a similar equilibrium exists for ethanol between the blood in the bronchiole circulation and the watery mucosal layer and still another equilibrium exists for mucosal surface and inspired air.⁴³ As inspired air passes over the mucosal surface, it picks up alcohol and, by the time the inspired air reaches the alveolar space, it is capable of absorbing only a small amount of additional alcohol.⁴⁴ Upon expiration, the reverse occurs: alcohol accumulated in the inspired air partitions back to the airway mucosa.⁴⁵

So, what does it matter where the alcohol comes from? Due to changes in temperature and humidity, the resultant alcohol concentration in the breath from the exchange at the mucous layer would underestimate the corresponding blood alcohol concentration to be less than that actually in the blood. This potential underestimation of BAC phenomenon results from a fundamental flaw in the assumptions underlying the design of breath alcohol testing apparatus and allows breath alcohol testing to be subject to variability (or even manipulation) through changes in breathing.⁴⁶ For example, 20 seconds of hyperventilation (excessive rate and depth of respiration leading to abnormal loss of carbon dioxide from the blood) decreases BrAC by 11%⁴⁷ and the breath alcohol concentration may be reduced by 4% following three deep breaths prior to the sample.⁴⁸ Alternatively, breath-holding prior to the sample breath increases BrAC by 12%

⁴² See Paradigm Shift.

⁴³ See *Id.* at 7-8.

⁴⁴ See Paradigm Shift.

⁴⁵ See *Id.*

⁴⁶ See *Id.* at 8-9.

⁴⁷ See Jones, A. How breathing technique can influence the results of breath-alcohol analysis. *Med. Sci. Law* 1982;22: 275-280.

⁴⁸ See Ohlsson, J., D. Ralph, M. Mandelkorn, A. Babb and M. Hlastala. Accurate measurement of blood alcohol concentration with isothermal rebreathing. *J. Stud.*

after 15 seconds (upon minimum exhalation) and 6% (upon maximum exhalation)⁴⁹ and 16% following a 30 second hold.⁵⁰

Manipulating breathing patterns, i.e., holding one's breath or hyperventilating, changes the amount of alcohol in the sample breath because of changes in the temperature of the airway mucosal lining.^{51 52} As cooler air enters the lungs, it is warmed and humidified as it travels inward towards the alveoli.⁵³ During exhalation the warm and humid deep lung air loses heat and moisture to the mucosa as it moves upward and outward.⁵⁴ Since ethanol is highly soluble in water,⁵⁵ exchange between the air and the mucosal surface is significant⁵⁶ and changes in humidity and temperature have very important implications for the exchange of ethanol between the respiratory mucosa and the air.⁵⁷

As inspired air absorbs heat, water vapor and ethanol from the mucosal surface,⁵⁸ ethanol becomes more soluble in the cooler environment of the mucosal lining resulting in a decrease in the partial pressure of ethanol and a subsequent decreased uptake of ethanol into the inspired air.⁵⁹ When the air reaches the alveoli only a small amount of additional ethanol exchange takes

Alc. 1990;51: 6-1.

⁴⁹ *See Id.*

⁵⁰ *See Jones, A. How breathing technique can influence the results of breath-alcohol analysis. Med. Sci. Law. 1982;22: 275-280.*

⁵¹ *See Jones, A. Quantitative measurements of the alcohol concentration and the temperature of breath during a prolonged exhalation. Acta Physiol. Scand. 1982;114: 407-412.*

⁵² *See Tsu, M., A. Babb, E. Sugiyama and M. Hlastala. Dynamics of soluble gas exchange in the airways: II. Effects of breathing conditions. Respirat. Physiol. 1991;83: 261-276.*

⁵³ *See Paradigm Shift at 6.*

⁵⁴ *See Id.*

⁵⁵ *See <http://www.sciencedaily.com/articles/s/solubility.htm> (last visited July 19, 2009)*

⁵⁶ *See Paradigm Shift at 6. See also Ohlsson, J., D. Ralph, M. Mandelkorn, A. Babb and M. Hlastala. Accurate measurement of blood alcohol concentration with isothermal rebreathing. J. Stud. Alc. 1990;51: 6-1. and Tsu, M., A. Babb, E. Sugiyama and M. Hlastala. Dynamics of soluble gas exchange in the airways: II. Effects of breathing conditions. Respirat. Physiol. 1991;83: 261-276).*

⁵⁷ *See Id.* at 6.

⁵⁸ *See Paradigm Shift.*

⁵⁹ *See Paradigm Shift at 6-7.*

place.⁶⁰ As the flow of air or breath reverses, the warmer more humid air is cooled, water condenses on the mucosal surface and the ethanol equilibrium reverses.⁶¹ Ethanol in the air then partitions into the water of the mucosal surface.⁶²

Alcohol uptake from, and deposition on, the mucosal surface varies as air moves through the respiratory tract with areas of greater and lesser ethanol exchange. The trachea and upper airways are the areas of greatest alcohol uptake and deposition.⁶³ Because of the bimodal nature of the ethanol uptake-deposition profile when viewed as a function of position in the respiratory tract, the ethanol delivered to a breath alcohol testing device has been delivered into the breath sample from the trachea and upper airways, not the alveolar space.⁶⁴

Are changes in breath alcohol concentration because of changes in breathing patterns observational proof of the new paradigm? In the analysis of the software for the Alcotest, the Special Master's Report makes note of, and accepts, the "black box" testing that was conducted.⁶⁵ The "black box" technique essentially assumes that, for a given input, if the expected outcome is observed, then the system is functioning properly. Applying this approach to the evaluation of gas exchange phenomena, since the expected outcomes from alterations in breathing pattern are obtained, i.e. decreases in BrAC with hyperventilation and increases BrAC with deep slow breathing immediately preceding sampling, then the gas exchange paradigm cannot be one that assumes a constant and unchanged alveolar concentration but rather one that explains the changes by allowing for additional gas exchange to occur after the air has left the alveolar space.

⁶⁰See [Jones AW](#). Determination of liquid/air partition coefficients for dilute solutions of ethanol in water, whole blood, and plasma. [J Anal Toxicol](#). 1983;7(4):193-7.

⁶¹ See Paradigm Shift.

⁶² See *Id.* at 6.

⁶³ See *Id.* at 7-8.

⁶⁴ See *Id.* at 8.

⁶⁵ See SMR at 241.

B. Body Temperature

A small difference in body temperature can make a big difference with respect to the guilt or innocence of DUI defendants when the BAC is close to the legal limit.⁶⁶ The widely used blood-to-air partition ratio for ethanol of 2100:1 is based on a normal body temperature of 98.6⁰ F.⁶⁷ A higher body temperature will result in an overestimate of the actual BAC because of the higher volatility of compounds like ethanol at higher temperatures.⁶⁸ For example, an increase in body temperature of 1⁰ C (1.8⁰ F) results in a 7% higher estimated BAC result, so a person with a body temperature of 100.4⁰ F⁶⁹ and with an actual blood alcohol of 0.0935 % would theoretically register a value of 0.10 % by the breath test.⁷⁰

C. Breath Temperature

Theoretical considerations of ethanol equilibrium aside, the temperature of the sample breath has a significant impact on the BrAC.⁷¹ In addition to body temperature, breath temperature is important in several respects. The partition coefficient of 2100:1 is based on the assumptions that: (1) the average temperature of exhaled air is 93.2⁰ F⁷² while temperatures as low as 31 degrees Celsius (88 degrees Fahrenheit) have been reported in the literature dealing with breath-alcohol analysis for breath leaving the mouth and (2) the vapor pressure⁷³ of alcohol for air/blood and air/water systems changes drastically in the relevant temperature range.⁷⁴

⁶⁶ See Melethil SK. Breath tests for blood alcohol determination: Partition ratio at http://www.forensic-evidence.com/site/Biol_Evid/Breath_Tests.html (last visited July 19, 2009).

⁶⁷ See *Id.*

⁶⁸ See *Id.*

⁶⁹ 1.8 degrees higher than the normal 98.6 degrees F

⁷⁰ See Melethil SK. Breath tests for blood alcohol determination: Partition ratio at http://www.forensic-evidence.com/site/Biol_Evid/Breath_Tests.html (last visited July 19, 2009).

⁷¹ See *Id.*

⁷² See *Id.*

⁷³ See <http://www.chem.purdue.edu/gchelp/liquids/vpress.html> (The vapor pressure of a liquid is the equilibrium pressure of a vapor above its liquid) (last visited July 20, 2009)

⁷⁴ See Dubowski K. Biological aspects of breath-alcohol analysis. *Clin. Chem.* 1974;20(2):294-299.

The partition coefficients for alcohol increase by 9% per degree over the range of 30 degrees to 40 degrees Celsius (86 degrees and 104 degrees Fahrenheit).⁷⁵ Therefore, the amount of alcohol in cooler breath leaving the mouth should already be different than that in warmer deep lung air and those amounts themselves will fluctuate with changes in core body and upper respiratory tract temperature.⁷⁶ Additionally, the cooling of expired air as it leaves the mouth and enters the mouthpiece of the breath alcohol testing device may result in condensation in the mouthpiece, thereby removing alcohol from the expired air further affecting the determination of BAC.⁷⁷

D. Lung volume

All currently available breath alcohol testing devices require a certain minimum volume of breath before sampling occurs.⁷⁸ This is generally 1.5 liters for the Alcotest, but in New Jersey the minimum volume is decreased to 1.2 liters for females over 60.⁷⁹ The ethanol concentration of a given breath is not uniform throughout the entire period of exhalation.⁸⁰ The concentration of alcohol in expired breath increases over the course of expiration; the slope of the increase is very steep (nearly vertical) at first, then it begins to become shallower, but never actually “levels off” or plateaus.⁸¹ As soon as air from the test subject begins to enter the IR chamber the alcohol content measured by the device begins to increase.⁸² Lung volume, and

⁷⁵ See Dubowski K. Biological aspects of breath-alcohol analysis. Clin. Chem. 1974;20(2):294-299.

⁷⁶ See *Id.*

⁷⁷ See Melethil SK. Breath tests for blood alcohol determination: Partition ratio at http://www.forensic-evidence.com/site/Biol_Evid/Breath_Tests.html (last visited July 19, 2009).

⁷⁸ See Paradigm Shift.

⁷⁹ See *State v. Chun*, 194 N.J. 54 (N.J. 2008).

⁸⁰ See *Id.*

⁸¹ See George SC, Babb AL, Hlastala MP. Dynamics of soluble gas exchange in the airways. III. Single-exhalation breathing maneuver. J Appl Physiol. 1993;75(6): 2439-2449 at 2443.

⁸² See George SC, Babb AL, Hlastala MP. Dynamics of soluble gas exchange in the airways. III. Single-exhalation breathing maneuver. J Appl Physiol. 1993;75(6): 2439-2449 at 2443.

consequently the proportion of an individual's vital capacity that the sample represents,⁸³ may have dramatic impact on the amount of alcohol contained in the breath at the time of sampling.⁸⁴

The lack of plateau is significant because current breath alcohol testing devices are designed with the assumption that alcohol content of breath is uniform once the dead space, both anatomic and within the machine, are cleared.⁸⁵ If this assumption was correct, the total volume of expired air obtained from the test subject would not matter once the dead space was cleared so the subject's vital capacity would not be an issue. However, because the BrAC does not plateau as originally thought but rather continues to rise throughout the exhalation, those subjects with overall smaller vital capacities exhale a greater proportion of that capacity in order to satisfy the minimum volume requirement of the measuring device.⁸⁶ This results in a higher BrAC for a given BAC in persons with decreased vital capacities. That is because, in exhaling a greater portion of their vital capacity, such persons reach a portion of their "alcohol concentration versus percent of vital capacity" curve where the alcohol concentration of the expired air is greater than at lower percentages of vital capacity. For example, a 60 year old, five foot tall female must exhale 60% (1.5L/FVC of 2.5L) before acceptance and a 20 year old, six foot two inch male must exhale only about 24% (1.5L/ FVC of 6.3L) before acceptance. Even at the decreased amount of 1.2L required for women over 60 in New Jersey, this is still 48% of vital capacity.

Lung volume increases in proportion to the cube of height⁸⁷ and is generally greater in males than females. Merely decreasing the sample size required for females over 60 does not adequately adjust for those individuals with respiratory diseases that decrease or restrict lung

⁸³ See <http://www.fpnotebook.com/Lung/Lab/VtlCpcty.htm> (last published 7/1/09)

⁸⁴ See [Hlastala MP](#). The alcohol breath test--a review. *J Appl Physiol*. 1998 Feb;84(2):401-8

⁸⁵ See *Id.*

⁸⁶ See Paradigm Shift.

⁸⁷ See Hepper NG, Fowler WS, Hemlholtz HF. Relationship of height to lung volume in healthy men. *Dis. Chest* 1960; 37314-320.

volume such as asthma or emphysema or individuals of smaller stature who naturally have smaller lung volumes. Since the BrAC continues to increase with amount of breath expired, this phenomenon biases breath alcohol testing against those with smaller vital capacities.⁸⁸

Measuring breath alcohol

A. Infrared spectroscopy

Infrared radiation is that portion of the electromagnetic spectrum beginning with wavelengths immediately above (longer wavelengths) the visible spectrum, wavelengths of about 7.8×10^{-5} cm, and ending at approximately 10^{-2} cm (just below microwave radiation wavelength).⁸⁹ Identification by infrared absorption is based on the concept that different molecules each have unique absorption spectra based on the types and arrangements of atoms within the molecule.⁹⁰ Infrared (IR) spectroscopy uses data regarding the wavelength and/or amount of infrared radiation absorbed by a substance to identify and/or quantify the amount of the substance present.⁹¹ When used for the purpose of identifying an unknown organic molecule or verifying the presence of a particular compound the spectrum of absorption is used in a “fingerprint”-like manner.⁹² However, with respect to breath alcohol testing, a variant of IR spectroscopy known as “quantitative IR” is employed. Quantitative IR is concerned with not merely identifying but also with measuring the amount or concentration of a given substance

⁸⁸ See Paradigm Shift.

⁸⁹ See John McMurry, Organic Chemistry, chapter 11 (Brooks/Cole Publishing Company 1984). [hereinafter “McMurray”]

⁹⁰ See *Id.* at 352.

⁹¹ See Hamed M. Abdou Remington’s Pharmaceutical Sciences 625-628 (Alfonso R. Gennaro ed., Mack Publishing Company 1985) (1886). [hereinafter “Remington’s”]

⁹² See McMurray at 355.

present in the sample. Quantification is achieved by measuring the amount of IR energy absorbed.⁹³

The absorption of infrared light can be used to determine the concentration of a given sample by following, if in this case the somewhat ironically named, Beer's Law.⁹⁴ The amount of light transmitted (% transmittance) through the sample from the source to the receiver declines logarithmically as concentration increases, meaning that the amount of infrared light that is absorbed increases as concentration increases.⁹⁵ By knowing the infrared fingerprint of ethanol and measuring the amount of infrared energy absorbed at one or more of those wavelengths by a given sample of breath, one can determine the concentration of ethanol in that sample.⁹⁶

However, while molecules have unique IR fingerprint absorption spectra, those spectra are complex and are often comprised of multiple absorption peaks.⁹⁷ For example, ethanol has strong characteristic absorption peaks at 3 and approximately 3.4 micrometers, a broad peak at about 7, two sharp peaks at approximately 9.1 and 9.5 and another at about 11.2 micrometers.⁹⁸ Thus, molecules and their absorption spectra are comprised of smaller units of atoms called functional groups, each with its own absorption characteristics.⁹⁹ Only when the constituent absorption spectra are combined and viewed hierarchically at the "whole molecule" level does the characteristic fingerprint spectrum become evident. Thus, focusing on absorption in only one wavelength may decrease the specificity of the analysis.¹⁰⁰

With respect to the Alcotest, IR analysis is performed in the following manner. The apparatus contains an IR light source and a detector, which determines the intensity of the

⁹³ See Remington's at 627.

⁹⁴ Also known as the Beer-Lambert Law.

⁹⁵ See Remington's at 623.

⁹⁶ See Remington's at 627.

⁹⁷ See McMurray at 354-55.

⁹⁸ See *Id.* at 353.

⁹⁹ See McMurray at 352-355.

¹⁰⁰ See <http://www.prenhall.com/settle/chapters/ch15.pdf> (last visited July 21, 2009).

infrared light source. When a breath containing alcohol is introduced into the chamber some of the infrared light is absorbed by the alcohol molecules and therefore does not reach the detector. A comparison between the pre-sample infrared transmission and the infrared transmission with the sample indicates that a lesser amount of infrared light reaches the detector with the sample present. The Alcotest equates the quantitative difference in the amount of infrared light reaching the detector to a blood alcohol concentration and a printed result is provided.¹⁰¹

B. Electrochemical fuel cell measurement

In addition to the infrared detection system, the Alcotest also contains a fuel cell that produces an electric current when exposed to alcohol.¹⁰² Electrochemical fuel cell sensors measure the amount of electric current (free electrons) produced when ethanol is oxidized to acetaldehyde producing a current directly proportional to the amount of alcohol present.¹⁰³ Fuel cells are comprised of two platinum electrodes separated by an electrolyte.¹⁰⁴ The electrode-electrolyte assembly is enclosed in an airtight case in which there is an intake port to expose the electrodes to a portion of the breath sample.¹⁰⁵ The platinum electrodes will oxidize any alcohol present in the breath sample and produce an electric current.¹⁰⁶ A microprocessor then measures the electric current, which can be correlated with concentration of ethanol in the breath sample.

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¹⁰¹ See *Foley*, 370 N.J. Super. at 346.

¹⁰² See *Id.*

¹⁰³ See http://books.google.com/books?id=mxd-EWYxY1oC&pg=PA36&lpg=PA36&dq=alcohol+breath+test+fuel+cell+acetaldehyde&source=bl&ots=666XfwG_tti&sig=T7cqCIPTc02b0r2DFxLP24alq8U&hl=en&ei=INhjStOsHuqStgeRuvz_Dw&sa=X&oi=book_result&ct=res ult&resnum=3(last visited July 19, 2009) (describing the process of oxidation of ethanol to generate electrical current).

¹⁰⁴ See <http://www.breathalyzeralcoholtester.com/how-breathalyzer-works/> (last visited July 19, 2009).

¹⁰⁵ See <http://www.intox.com/fuelcell.asp> (last visited July 19, 2009).

¹⁰⁶ See *Id.*

¹⁰⁷ See http://www.craigmedical.com/Breathalyzer_FAQ.htm (last visited July 19, 2009).

Electrochemical fuel cells are ethanol-specific so there is little risk of cross-reaction with interference or contaminants.¹⁰⁸ When alcohol is introduced into the fuel cell, electrons flow between the anode and cathode in the fuel cell, and the Alcotest interprets this increase in the electric current as alcohol in the breath.¹⁰⁹

The Alcotest as Compared to Other Breath Alcohol Testing Devices

It is beyond the scope of this paper to perform an exhaustive comparison of breath alcohol testing devices and to determine the superiority of any particular device or devices. However, in at least one respect, courts in New Jersey and other states may be laboring under the false assumption that the Alcotest provides a higher standard of certainty in breath alcohol test results than previously available.

The Alcotest has been described by courts in New Jersey as “an evidential breath testing instrument which uses infrared (IR) absorption analysis and electrochemical (EC) cell technology analysis to simultaneously determine the presence of ethanol in a breath sample. Each method of analysis operates independently”¹¹⁰ and as “the only evidential breath-testing instrument which uses a dual system of IR absorption analysis and EC fuel cell technology to independently measure alcohol concentration in the same breath sample.”¹¹¹ But are these descriptions accurate?

On its face, the Alcotest seems to be distinguishable from other breath alcohol testing devices. The Alcotest uses infrared transmission and absorbance in the 9.5 micron range to

¹⁰⁸ See <http://www.intox.com/fuelcell.asp> (last visited July 19, 2009).

¹⁰⁹ See *Foley*, 370 N.J. Super. at 346.

¹¹⁰ See *Id.*

¹¹¹ See *Chun*, 2007 N.J. LEXIS 39 at *37.

diminish the influence of other substances, such as acetone, acetaldehyde and other ketones which are commonly present in human breath.¹¹²

Additionally, the Alcotest purports to be the only breath alcohol testing device to incorporate the dual technologies of quantitative infrared absorption spectroscopy and electrochemical or fuel cell technology.¹¹³ Theoretically, this allows the Alcotest to internally validate its own findings by comparing the alcohol concentration determined by the infrared absorption method with that of the fuel cell oxidation method.¹¹⁴

Despite the presence of the two distinct technologies, which are advertised as working independently and thus providing a mutual check on each other, the Alcotest does not utilize two independent measurement techniques. In short, the way the two “distinct” measurements are calculated are functions of each other, rendering the “independent” measurements anything but independent.

Specifically, the fuel cell measurement is a dependent function of the infrared determination.¹¹⁵ A problem inherent with fuel cell technology is “drift.” This phenomenon can be described as a slowing of the reaction rate of the fuel cell over time.¹¹⁶ The result is a lengthening of the time required for a full measurement of the alcohol present in a given sample. Because the time during which the Alcotest test results are collected may be shorter than the time required for the fuel cell to fully measure the alcohol present, a portion of the fuel cell result may be truncated, resulting potentially in an underreporting of the amount of alcohol present.¹¹⁷

¹¹² See *Chun*, 2007 N.J. LEXIS 39 at *61.

¹¹³ See *Chun*, 2007 N.J. LEXIS 39 at *37.

¹¹⁴ See *Chun*, 2007 N.J. LEXIS 39 at *64.

¹¹⁵ See Defendant’s initial brief after remand regarding source code at 11-13, *State v. Chun*, 2007 N.J. LEXIS 39 (N.J. Feb. 13, 2007).

¹¹⁶ See *State v. Pollock*, 407 N.J. Super. 100, 104 (App.Div. 2009).

¹¹⁷ See *Id.*

In order to compensate for the fuel cell drift, Draeger utilizes an algorithm where the fuel cell reading is compared to, and calibrated with, an infrared determination of alcohol content of sample of known concentration.¹¹⁸ Fuel cells measure the amount of electric current generated over time, the results are reported as a curve where the amount of current produced is reported over time and the area under the resultant curve represents the total amount of electricity generated.¹¹⁹ The area under the curve is used to determine the amount of alcohol present in the sample.¹²⁰ As the fuel cell ages, the rate of response slows and, although the total amount of electricity generated does not change, the time necessary for the full reaction does increase. This leads to a potential omission of portion of the generated fuel cell data if the data collection period of the device is less than that required for a complete fuel cell response.¹²¹

Draeger has included an algorithm in the Alcotest software to compensate for the fuel cell drift.¹²² The compensatory algorithm is notable in that, rather than attempting to estimate or extrapolate the portion of the fuel cell results not included in the sample period based on rates of reactions and slope of the curve, the algorithm merely increases the fuel cell result by up to 25% of the difference between the infrared and electrochemical readings.¹²³ Rather than preserving the independence of the fuel cell result, even if some portion of the result was estimated, this algorithm potentially subordinates the fuel cell result to the infrared reading and thus makes it a dependent measurement potentially eliminating the purported ability of the Alcotest to control for interferents. To a limited extent, New Jersey has recognized the inadequacy of the drift algorithm solution by requiring fuel cell recalibration every six months¹²⁴ although there is no

¹¹⁸ *See Id.*

¹¹⁹ *See* <http://www.intox.com/fuelcell.asp>. (last visited July 19, 2009).

¹²⁰ *See Id.*

¹²¹ *See State v. Pollock* 407 N.J. Super. at 104.

¹²² *See Chun*, 194 N.J. 54.

¹²³ *See Id.*

¹²⁴ *See Id.* at 123.

evidence to suggest that this solution will eliminate the drift issue¹²⁵ and does not cure the flawed algorithm methodology.

¹²⁵ See Defendant's initial brief after remand regarding source code at 17-18, *State v. Chun*, 2007 N.J. LEXIS 39 (N.J. Feb. 13, 2007).

PART III: STATE V. CHUN

The case of *State v. Chun* arose from claims made by twenty individuals who were all convicted of driving while intoxicated under N.J.S.A. 39:4-50 which, in relevant part, states that a person who “operates a motor vehicle while under the influence of intoxicating liquor . . . or operates a motor vehicle with a blood alcohol concentration of 0.08%” or more by weight of alcohol in the defendant’s blood is guilty of DUI.¹²⁶ Their case rested on three main challenges:

1. The “first set of challenges related to how [Alcotest] measures a suspect’s blood alcohol concentration.” These challenges are discussed above in Part Two.
2. “The next set of challenges related to the Alcotest's programming and source code.” These challenges are addressed in this section.
3. “The third set of challenges related to the admissibility of Alcotest results and foundational documents as potentially violating Sixth Amendment rights under *Crawford v. Washington*.”¹²⁷ This matter is not addressed in the report.

The New Jersey Superior Court, Law Division, consolidated the claims challenging the admissibility of the blood-alcohol test results produced by the Alcotest.¹²⁸ Subsequently, the State moved to have the Alcotest results admitted into evidence without the need for expert testimony pursuant to *State v. Foley*,¹²⁹ in which the court ruled that the Alcotest was scientifically reliable.¹³⁰ The State’s motion, however, was denied.¹³¹ The Judge found that,

¹²⁶ N.J. Stat. § 39:4-50.

¹²⁷ 541 U.S. 36 (2004).

¹²⁸ *State v. Chun*, 194 N.J. 54, 66 (N.J. 2008).

¹²⁹ *State v. Foley*, 370 N.J. Super, 341, 359 (Law Div. 2003).

¹³⁰ *Id.* at 67.

¹³¹ *Chun*, 194 N.J. at 66.

because the Alcotest was a novel scientific instrument,¹³² which neither an appellate court nor the New Jersey Supreme Court had ever vetted; its scientific reliability remained a justiciable issue.¹³³

The State appealed the decision of the Superior Court, and the Appellate Division granted the appeal and remanded the matter back to the trial court for a hearing regarding the admissibility of the claimants' Alcotest results.¹³⁴ At this point, the Supreme Court of New Jersey stepped in. The Supreme Court certified the appeal pending before the Appellate Division on its own motion and then vacated the remand to the Law Division. The Supreme Court took on the task of "address[ing] the scientific reliability of the Alcotest... and consider[ed] the admissibility of the Alcohol Influence Reports (AIRs)¹³⁵ that it generates for the prosecution of defendants under New Jersey drunk driving laws."¹³⁶

In order to accomplish this objective, the Supreme Court assigned the case to a Special Master, retired Appellate Judge Michael P. King, to assist in determining the reliability of the Alcotest.¹³⁷ The Special Master issued a discovery order asking the State to provide technical information concerning the Alcotest in addition to making several of the machines available to both the defendants and the New Jersey State Bar Association.¹³⁸ Thereafter, a dispute arose regarding disclosure of the Alcotest software.¹³⁹

¹³² Calling the Alcotest a "novel scientific instrument" means that any analysis presented using data from the Alcotest should be open to the same discovery as that from other "novel scientific instruments." This makes breath alcohol testing fundamentally no different from drug testing and should be treated as such.

¹³³ *Chun, 194 N.J. at 66.*

¹³⁴ *Id.*

¹³⁵ While the State changed instrument and measuring procedures, it did not change the AIR. This is a serious omission.

¹³⁶ *Chun, 194 N.J. at 66.*

¹³⁷ *Id.*

¹³⁸ *Id.* at 68.

¹³⁹ *Id.*

The challenge to the Alcotest's programming and source code introduced an interesting, but not uncommon, twist. When New Jersey had contracted with Draeger for the Alcotest, Draeger had successfully lobbied to have the source code declared a trade secret and consequently New Jersey had purchased a "black box": the machines could be purchased by the state and utilized by law enforcement, but no one outside of Draeger was permitted to know exactly how they worked. Indeed, no one was permitted to try to ascertain how they worked; in the language of Draeger's contract, no one could "reverse engineer, decompile or disassemble the Firmware/Software or otherwise attempt to derive source codes from the Firmware/Software, nor shall Licensee allow any other entity to do so."¹⁴⁰ Certainly such language is not unusual or exceptional when trade secrets are involved, and, indeed, a few other states have similar contracts involving breathalyzer-type machines.¹⁴¹ However, the twist this contract introduced became apparent during the discovery phase of the proceedings. The State, the party of the case, did not have the source code that defense counsel requested, and the party that did have the source code, Draeger, had effectively been immunized from providing it.

Draeger objected to the discovery request and its intellectual property counsel prepared a proposed protective order for the Court. Draeger's proposal included a request for indemnification from defense counsel.¹⁴² Upon the defense's objection, Draeger offered to allow the Special Master to view the source code during an *in camera* session provided there would be no testimonial record, and all material would be returned after inspection.¹⁴³ Again the defense

¹⁴⁰ See *State v. Chun*, 2007 N.J.LEXIS 39, at *30 (N.J. Feb. 13, 2007).

¹⁴¹ States in similar situations include Connecticut, New York, Florida and Georgia. An exception is Minnesota, which has contractually provided for source code access. See 61 Fla. L. Rev. 177, 188.

¹⁴² *State v. Chun* Special Master's Report, 9-10.

¹⁴³ *Id.*

objected, as the purpose of the discovery request was to have an independent expert review and test it.¹⁴⁴

A number of subsequent protective orders were devised by defense and the State, all of which were deemed insufficient by Draeger; details of these efforts can be found in the Special Master's report.¹⁴⁵ An extended excerpt from the Special Master's report, included below, illustrates Draeger's position.

For example, Draeger contended: it should be provided with the identity of experts who would be given the marked information in discovery; it should not have to appear before the Special Master at a hearing to demonstrate irreparable harm; it should be allowed to demonstrate its intellectual property rights or prove its need for injunctive relief in a forum other than before Judge King; and it should not be forced to comply with an order essentially based upon a proposal by defendants who did not have any trade secrets or proprietary information to be protected.

Draeger also advised the Special Master and the State that it "recently" had adopted a "new policy" regarding confidential disclosure of the Alcotest 7110's source codes and other trade secrets to those individuals, including parties involved in the Chun litigation, who accepted the following conditions: (1) individuals who agreed to sign appropriate non-disclosure and confidentiality agreements prepared by Draeger; (2) individuals who agreed to review the information in a room at Draeger's offices in Durango, Colorado; (3) individuals who agreed to allow a Draeger representative to be present in the room when they reviewed the information; and (4) individuals who agreed not to take photographs, make copies by writing or other means, or make any recordings of the information. To maintain its "non-party status," Draeger again declined the Special Master's offer to meet with him or participate in any conferences.¹⁴⁶

Unsurprisingly, "[n]either the State nor the defendants expressed any interest in complying with Draeger's fastidious conditions on the source codes' disclosure."¹⁴⁷ Discovery

¹⁴⁴ *Id.*

¹⁴⁵ *Id.* at 10-12.

¹⁴⁶ *Id.*

¹⁴⁷ *Id.*

proceeded without Draeger's participation. As the Special Master noted, this created an "anomalous" situation: Draeger was exempt from defending its own product.¹⁴⁸

Draeger never provided the Court, the State or the defense with the source code. However, the Special Master "issued a supplemental order allowing each of the parties, at its own expense, to designate an independent software house to review the source code."¹⁴⁹ After a long debate regarding the propriety and availability of the Alcotest's source code, the parties finally reached an agreement. Draeger contracted SysTest Labs, Inc. ("SysTest"), a Colorado based firm that conducts software testing, to a review the Alcotest source code.¹⁵⁰ The defendants engaged Base One Technologies, Inc. ("Base One"), a New York-based support firm specializing in information technologies, to perform their review.

Ultimately, both Base One and SysTest determined the source code for the Alcotest contained flaws; however, they reached different conclusions as to the reliability of the machine. SysTest identified two main problems within the Alcotest's source code, but stated that both were outside the scope of the Court's order. Specifically, the SysTest analysis found issues with the complexity of the code and buffer overflow, but still concluded that the code as written and used in accordance with Draeger's guidelines would "reliably produce consistent test results." Base One's evaluation, on the other hand, uncovered 24 "major defects," nine of which had a significant impact on Alcotest test results.¹⁵¹ Base One also reported that there were defects in three out of every five lines of code and concluded that "[a]s a matter of public safety, the

¹⁴⁸ *Id.*

¹⁴⁹ State v. Chun, 194 N.J. 54, 70 (N.J. 2008)

¹⁵⁰ McName, Geller, Pollich & Phillips, *Assessment Report for Draeger Safety Diagnostics, Inc. Alcotest 7110 MKIII-C. New Jersey Firmware Version NJ 3.11* (SysTest Labs, Inc., 2007); Systest Labs Inc., <http://www.systest.com/news/97-systest-labs-redefines-voting-systems-testing-protocols-for-the-21st-century> (last viewed July 6, 2009).

¹⁵¹ John J. Wisniewski, *DSDI Static Code Review and Analysis Findings Report. Report on Behalf of the Defendants on the Alcotest 7110 MKIII-C New Jersey Firmware Version NJ3*, 3-6 (Base One Technologies, Inc., 2007). The nine major alleged defects are listed in Part B in this section.

Alcotest should be suspended from use until the software has been reviewed against an acceptable set of software development standards.”¹⁵²

The supplemental order allowed the Special Master, at his discretion, to conduct further hearings following his receipt and review of the expert reports. The Special Master took ten more days of expert testimony and announced his conclusion: the “source code analysis did not alter his original opinion that the Alcotest is scientifically reliable, as to both its hardware and software elements.”¹⁵³ His initial findings were contingent on his recommendation “that several changes be incorporated both prospectively and with respect to pending matters.”¹⁵⁴

Source Code Findings

We sketch here the findings of the respective findings of the independent software experts regarding the Alcotest source code. Source code is the set of “instructions followed by the computing device in processing information.”¹⁵⁵ Quite literally, the source code tells the device what to do, governing every step of the machine’s function from start to finish. Defendant access to source code of breath alcohol testing is of particular importance because the analysis may result in a per se violation of the law.¹⁵⁶ As noted previously, however, states are not generally able to provide the source code to defendants, since in purchasing or leasing the devices they do not obtain ownership of the source code and are therefore unable to provide it at discovery.¹⁵⁷ Likewise, defendant attempts to gain access to the code from the manufacturer by

¹⁵² *Id.* at 28.

¹⁵³ *State v. Chun*, 194 N.J. 54, 70 (N.J. 2008)

¹⁵⁴ *Id.*

¹⁵⁵ *Id.*

¹⁵⁶ *Id.*

¹⁵⁷ [People v. Robinson](#), 2008 NY Slip Op 5533, 1 (N.Y. App. Div. 2d Dep’t 2008)

traditional methods of discovery are frustrated because the Alcotest manufacturer is not a party to the proceedings and because of trade secret doctrine.

A. SysTest's Evaluation of the Alcotest Source Code

SysTest's summary, while noting that "the reviewed source code is not written in a manner consistent with usual software design best practices," identified only two issues with the Alcotest source code. The first related to the source code complexity and makeup, and the second was a specific instance where a buffer flow error could occur, thus accidentally deleting data. However, SysTest felt that "in our opinion, [both issues] were outside the scope of The [Court's] Order,"¹⁵⁸ concluding that if the Alcotest is always used according to the manufacturer guidelines, "there are no obvious defects *intentionally* written to produce anything other than consistent test results."¹⁵⁹ (emphasis added).

SysTest stated that the Alcotest source code was "not written in a manner consistent with usual software design best practices,"¹⁶⁰ and described the code as "highly complex,"¹⁶¹ demonstrated by the number of independent pathways in the code.¹⁶² This is referred to as cyclomatic complexity.¹⁶³ Not surprisingly, the more paths in a code the more complex and more difficult it is to understand, and the higher the risk of "inherent defects."¹⁶⁴ Coding standard guidelines recommend that a source code's complexity have a value "no greater than 10"¹⁶⁵ and further "recommend keeping it under 7."¹⁶⁶ According to SysTest, the Alcotest's

¹⁵⁸ McName, Geller, Pollich & Phillips, *Assessment Report for Draeger Safety Diagnostics, Inc. Alcotest 7110 MKIII-C. New Jersey Firmware Version NJ 3.11*, 3 (SysTest Labs, Inc., 2007).

¹⁵⁹ *Id.* at 4.

¹⁶⁰ *Id.*

¹⁶¹ *Id.* at 3.

¹⁶² *Id.* at 22.

¹⁶³ *Id.*

¹⁶⁴ *Id.* at 23.

¹⁶⁵ *Id.*

¹⁶⁶ *Id.*

code has 81 modules with a cyclomatic complexity in excess of 10, and three modules with indices in excess of 100.¹⁶⁷

Next, SysTest identified a “buffer overflow” error within the code. This error could occur in circumstances when a third breath sample is required (two are typically taken), and would cause a reported breath test result to be invalidated.¹⁶⁸ SysTest does not further analyze the issue, but maintains that the measured alcohol concentration values are correctly retained and reported in the Alcohol Influence Report (AIR).¹⁶⁹

As a final note, in order to conduct its analysis, SysTest used a program developed “in-house” by SysTest known as Model Finder Ex,¹⁷⁰ which, according to the testimony of a senior software quality engineer at SysTest, does not itself adhere to industry standards.¹⁷¹ This creates the odd situation in which a program not adhering to software development standards is utilized to evaluate whether another program is likely to be accurate and reliable.

B. Base One’s Evaluation of the Alcotest Source Code

Base One’s evaluation of Alcotest source code uncovered 24 “major defects.” The evaluation also revealed defects in three out of every five lines of code.¹⁷² Among them, the nine that most impact test results are listed below:

- (1) [T]he software would not pass industry standards for development and testing;
- (2) the lack of use of industry coding standards prevented the testing of all critical paths in the software;
- (3) the catastrophic error detection was disabled, making it difficult to detect if the software was executing indefinite branching or invalid code;
- (4) the implemented design lacked positive feedback;
- (5) the diagnostic routines were performed during data measurement cycles, allowing the

¹⁶⁷ *Id.* at 3.

¹⁶⁸ McNamé, Geller, Pollich & Phillips, *Assessment Report for Draeger Safety Diagnostics, Inc. Alcotest 7110 MKIII-C. New Jersey Firmware Version NJ 3.11*, 4 (SysTest Labs, Inc., 2007).

¹⁶⁹ *Id.*

¹⁷⁰ *Id.* at 6.

¹⁷¹ Transcript of Record at 2RT155, *State v. Chun*, 2007 N.J. LEXIS 39 (N.J. Feb. 13, 2007) (No. 58,879).

¹⁷² *Id.* at 26.

substitution of arbitrary data values when a routine failed; (6) the air flow readings were adjusted at the beginning of the measurement, causing defective measurements when the baseline value was corrupted; (7) the error detection logic failed to flag an error unless it occurred thirty-two times; (8) the heavy use of global variables failed to insulate software modules; and (9) the software instructions were out-of-phase with the continuously operating timer interrupt routine, which went off every 8.192 milliseconds.¹⁷³

Base One concluded that the problems with the Alcotest source code would take a year to correct,¹⁷⁴ expressed concern for the rights of those who are “not under the influence . . . [being] wrongfully accused and/or convicted,” and, as mentioned before, recommended that “the Alcotest should be suspended from use until the software has been reviewed against an acceptable set of software development standards.”¹⁷⁵

C. Further Issues

Both SysTest and BaseOne largely focused on whether and how well the source code got the Alcotest to perform the steps assigned to it. (Indeed, the SysTest report seems to focus more narrowly on whether there had been any attempt to “deliberately and/or maliciously alter or corrupt the software in order to generate inaccurate test results.”¹⁷⁶) Thus issues such as whether the steps conform to the believed function were not addressed. For instance, the fact that the Alcotest’s fuel cell measurement and its infrared measurement are not independently obtained,¹⁷⁷ contrary to Draeger’s claims, is not discussed.

Another consideration regarding the issue of source code is that of software updates. As with all software, the Alcotest requires updates when they arise, and these updates themselves

¹⁷³ John J. Wisniewski, *DSDI Static Code Review and Analysis Findings Report. Report on Behalf of the Defendants on the Alcotest 7110 MKIII-C New Jersey Firmware Version NJ3*, 3-6 (Base One Technologies, Inc., 2007).

¹⁷⁴ Transcript of Record at 8RT180, *State v. Chun*, 2007 N.J. LEXIS 39 (N.J. Feb. 13, 2007) (No. 58,879).

¹⁷⁵ BaseOne report, 28.

¹⁷⁶ SysTest report, 3.

¹⁷⁷ See Part II of this report.

require approval before the device goes into use.¹⁷⁸ The ability to ensure that the machine is reapproved after new software update installments would be of tremendous benefit to defense attorneys.¹⁷⁹ While physical inspection of the machines is allowed in most states, a physical inspection will not detect what effects the new source code will produce; in short, non-disclosure of source code after updates essentially allows the machine's functionality to be altered with no recourse for defendants regarding the effect of the changes.¹⁸⁰

If the AIR reports are indeed scientific reports, then the device must be made available for the scientific community to test, challenge, and corroborate—all the more so if the person designated to testify has no idea how the report was generated. In fact this point was recognized by the person designated by the State to investigate the Alcotest, the Special Master Michael P. King. Taking into account the concerns of the defense and the shortcomings of the device that had been uncovered in the proceedings, the Special Master concluded his opinion by affirming that the Alcotest would be “presumed reliable in our courts but only if the terms expressed in the attached Addendum A are scrupulously followed by Draeger.”¹⁸¹ Addendum A follows immediately, and condition (4) of the addendum reads as follows:

(4) Draeger agrees to sell to New Jersey attorneys and experts Alcotest 7110 MKIIC units on the same terms as are in force with the State of New Jersey at the time the purchase was made with the then-current version of the New Jersey software. Draeger also agrees to offer training to the purchasers and the purchaser's employees in regard to use of the Alcotest 7110 MKIIC on reasonable monetary terms and to warrant and service the instruments at the same rates as paid by the State of New Jersey. In the event that future software revisions take place, Draeger will facilitate upgrades of purchased Alcotest 7110 MKIIC units to the then-currently available New Jersey software version. (Although Draeger understands that this entire agreement is subject to review and reasonable approval by the State of New Jersey, this power is clearly within the

¹⁷⁸ Id.

¹⁷⁹ 61 Fla. L. Rev. 177, 179

¹⁸⁰ [State v. Bastos, 985 So. 2d 41 \(Fla. Dist. Ct. App. 3d Dist. 2008\)](#)

¹⁸¹ State v. Chun Special Master's Report at 236.

State's purview. *However, the intent of this clause is to make all current versions available to all non-governmental owners for a reasonable administrative fee.*) [emphasis added]¹⁸²

CONCLUSION

The legal issues in *State v. Chun* were many and complex, and they ranged from the use by law enforcement of proprietary products under strict nondisclosure agreements to the due process limitations on what might otherwise be a state's policy decisions for its criminal justice system. *Chun* obviously resolves state law issues for the State of New Jersey, but other jurisdictions may well make different policy choices if confronted with the same situation. In any event, the New Jersey Supreme Court cannot be the last word on the constitutionality of its foreclosure of individual defendants' challenge to the Alcotest in general or to the particular device used to measure their blood alcohol concentration. This Report does not try to address these questions but rather simply attempts to provide a scientific analysis, within the constraints entailed by the testing limitations imposed, for policy makers, courts, and litigants.

Finally, it is worth noting that the Alcotest, as with previous breath analyzers, "does not preserve the breath sample, so it is impossible to submit the sample for more sophisticated testing after the fact."¹⁸³ Without ongoing independent examination of the code there is no real way to test the accuracy of these machines, because the State itself does not know and cannot know how they arrive at their calculations. Somewhat surprisingly, to this point only one state, Minnesota, has acquired access to the source code of any breath analyzer,¹⁸⁴ even though a

¹⁸² *State v. Chun* Special Master's Report at 239-240.

¹⁸³ [State v. Bastos, 985 So. 2d 41 \(Fla. Dist. Ct. App. 3d Dist. 2008\)](#)

¹⁸⁴ [61 Fla. L. Rev. 177, 179](#)

majority of courts throughout the country have concluded that “a flaw in the source code would be consequential to the accuracy of the reading; thus such evidence would be relevant.”¹⁸⁵

¹⁸⁵ [House v. Commonwealth, 2008 Ky. App. LEXIS 19 \(Ky. Ct. App. Jan. 18, 2008\)](#)