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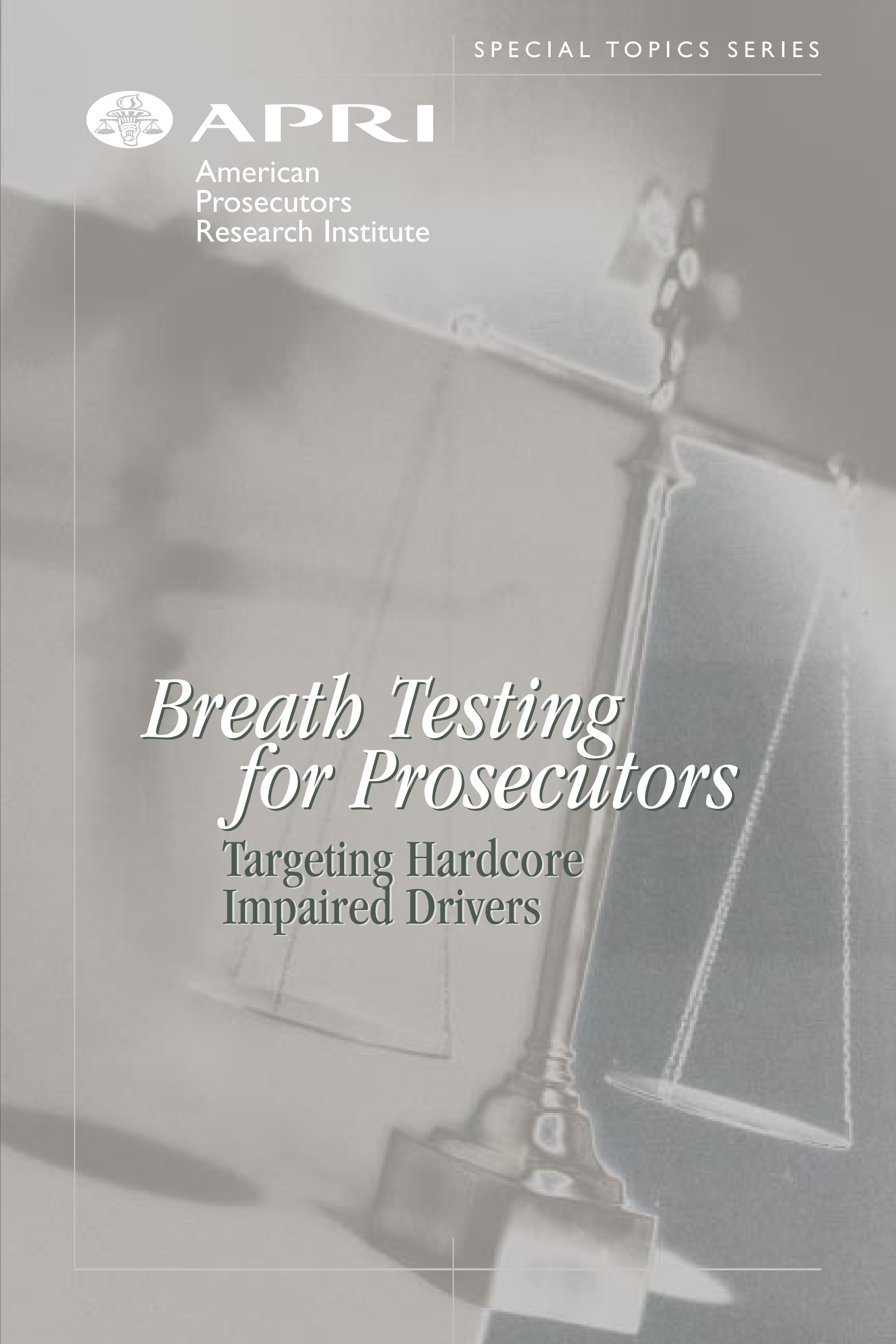

Breath Testing for Prosecutors

Targeting Hardcore Impaired Drivers

American Prosecutors Research Institute
99 Canal Center Plaza, Suite 510
Alexandria, VA 22314
www.ndaa-apri.org

Thomas J. Charron
President

Roger Floren
Chief of Staff

Stephen K. Talpins
Director, National Traffic Law Center

Debra Whitcomb
Director, Grant Programs & Development

George Ross
Director, Grants Management

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Breath Testing for Prosecutors

Targeting Hardcore Impaired Drivers

December 2004

Jeanne Swartz
Criminalist
Breath Alcohol Testing Program
Alaska Department of Public Safety

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Dedication

Our efforts are dedicated to the hundreds of thousands of impaired driving victims and their families and the thousands of professionals and advocates working to alleviate the impaired driving problem.

This monograph is dedicated to Mothers Against Drunk Driving (MADD) and the tens of thousands of MADD volunteers who promote traffic safety and offer support to the millions of people whose lives were changed by impaired drivers. In particular, we recognize Ms. Susan Isenberg. Ms. Isenberg is an active Mothers Against Drunk Driving (MADD) member in Miami-Dade County (MDC), Florida. She exemplifies all that is and can be.

In 1986, a 16-year-old impaired driver killed Ms. Isenberg's 17-year-old son, Christopher. Devastated by her loss, she endeavored to ensure that others would not have to suffer her son's fate. She joined MDC MADD almost immediately, assuming various leadership positions including MDC MADD President and Florida MADD Public Policy Liaison. With her guidance, MDC MADD grew into a vibrant, effective and supportive voice for South Florida's DUI victims.

Among her many accomplishments, Ms. Isenberg successfully lobbied for the enactment of various public safety laws, helped the state obtain millions of dollars in federal funds for DUI education and enforcement and initiated the local Victim Impact Panel.

Ms. Isenberg's efforts, and those of her many MADD colleagues, are invaluable. We can never thank them enough for the lives that have bettered and saved.

ACKNOWLEDGEMENTS

Impaired drivers are a scourge on society. More than 17,000 people died in alcohol- or drug-related car crashes in 2003. Another quarter-million were injured. Of course, statistics only tell part of the story. One can never place a numeric value on the pain and suffering impaired drivers cause.

In an effort to effectively address the problem, each state passed Driving Under the Influence (DUI) or Driving While Impaired (or Intoxicated) (DWI) "per se" laws. These laws criminalize driving with a blood or breath alcohol level (DUBAL) or concentration over 0.080. Law enforcement officers use breath-testing instruments to investigate the vast majority of these cases. Thus, prosecutors must understand the basics of breath alcohol testing. This monograph is designed to educate prosecutors about the basics of breath testing theories and procedures.

The author, Jeanne Swartz, is a criminalist assigned to oversee the breath alcohol-testing program with the Alaska Department of Public Safety. Jeanne has a Bachelor of Science degree in chemistry and a Master of Arts in teaching. She has worked for the Alaska Department of Public Safety for six years.

I would like to acknowledge and thank Mr. Lee Cohen, assistant state attorney in Broward, County Florida, Mr. Patrick Harding, Toxicology Section supervisor with the Wisconsin State Laboratory of Hygiene, Dr. Barry Logan, bureau director of the Forensic Laboratory Services Bureau with the Washington State Patrol, Ms. June Stein, district attorney for Kenai Borough in Alaska, and Mr. Chip Walls, director of the University of Miami Forensic Toxicology Department, for reviewing and contributing to this publication. Additionally, I would like to recognize the many prosecutors, law enforcement officers, and highway safety personnel whose thoughts and writings provided a foundation for this monograph. This publication would not have been possible without their wisdom and support.

Stephen K. Talpins
Director, APRI's National Traffic Law Center

Introduction

In 1933, Congress ended a decade of prohibition. Automobiles were abundant and alcohol widely available. The results were predictable: "drunk drivers" wreaked havoc. Impaired driving became a national issue and states passed Driving Under the Influence (DUI) of alcohol and Driving While Impaired (or Intoxicated) (DWI) by alcohol laws. In rural areas, police officers encountered problems contacting physicians and collecting blood samples for forensic analysis within a reasonable amount of time after stopping suspects. Police officers needed a tool to collect biological specimens for forensic analysis that did not require medical expertise. Inventors focused on developing instruments to measure urine and breath-alcohol levels.

Today, law enforcement officers and prosecutors around the world rely on breath alcohol testing to investigate and/or prove their DUI and DWI cases. They use preliminary breath testing devices (also known as pre-arrest breath testing devices or "PBTs") and passive alcohol screening devices to identify impaired drivers, evidential breath testing devices (EBTs) to prove their guilt, and ignition interlock devices to ensure that they do not drive under the influence again. These devices share similarities in sampling and, to some degree, in the analytical methods they use. All of them are capable of producing reliable results. However, EBTs are held to much higher administrative standards than screening devices; and are subjected to strict administrative controls and safeguards, including regular inspections and accuracy checks. This paper addresses EBTs only.

BREATH ALCOHOL TESTING

The Development of Breath Alcohol Testing

In the early 1930s, impaired driving became a national issue. However, the legal and scientific communities were ill equipped to address the burgeoning problem. Neither scientists nor legal scholars could define "impairment" or "under the influence." Further, conventional wisdom, even in educated circles, dictated that an experienced and skilled driver could compensate for alcohol's impairing effects. Finally, law enforcement officers lacked an easy, expeditious, and inexpensive means to measure blood alcohol concentration. The officers relied on blood and urine testing to measure alcohol consumption. However, each of these methods has substantial drawbacks. Blood testing is invasive, time consuming and expensive. Additionally, phlebotomists typically withdraw venous blood, which may be less reflective of actual impairment than arterial blood under some conditions. Finally, it is sometimes difficult for officers to find doctors and nurses to withdraw the blood and for prosecutors to procure their attendance at evidentiary hearings or trials. Although urine testing is less burdensome, the concentration of alcohol in urine also does not always correlate significantly with impairment. Researchers ultimately identified tools to address all of these issues: breath-alcohol testing and "per se" laws. A brief history of these developments follows[1]:

1927: Dr. Emil Bogen reported measuring blood alcohol concentration (BAC) by analyzing a person's breath. In 1938, Dr. R. L. Holcomb conducted further research into the risks associated with drinking alcohol and driving using the "Drunkometer," a breath-testing instrument invented by Professor Rolla Harger. In a study involving over 2,000 subjects, Holcomb calculated that the risk of causing an accident increased six times at a blood alcohol concentration (BAC) of 0.100 and 25 times at 0.150.[2]

[1]See A.W. Jones, "Fifty Years On - Looking Back at Developments on Methods of Blood- and Breath-Alcohol Analysis," www.jatox.com/abstracts/2001/nov-dec/index_title.htm-50k. For a detailed history of breath testing.

[2]See R. L. Holcomb, "Alcohol in Relation to Traffic Accidents," JAMA, 1076-1085 (1938).

1938: The National Safety Council's Committee on Alcohol and Other Drugs (COAD) (formally known as the Committee on Tests for Intoxication) collaborated with the American Medical Association's Committee to Study Problems of Motor Vehicle Accidents to establish standards for defining the phrase "under the influence." They based these standards, in large part, on Holcomb's research. They established three presumptive levels, defined in terms of *blood* alcohol concentration:

BAC	**Presumption**
0.000-0.049	"[N]o alcohol influence within the meaning of the law"
0.050-0.149	"Alcohol influence usually is present, but courts of law are advised to consider the behavior of the individual and circumstances leading to the arrest in making their decision"
0.150-Up	"Definite evidence of 'under the influence' since every individual with this concentration would have lost to a measurable extent some of the clearness of intellect and control of himself that he would normally possess"

1939: Indiana and Maine adopted these presumptions in their respective DUI statutes. The enactment of "presumptive levels" shifted the focus in DUI investigations and trials from officer observations to chemical testing.

1944: The National Committee on Uniform Traffic Laws and Ordinances incorporated presumptive alcohol concentrations in the Chemical Tests Section of the Uniform Vehicle Code. In 1948, the CAOD collaborated with Licensed Beverage Industries, Incorporated, to fund a research project at Michigan State College to study the efficacy of breath-testing methods. They examined the Drunkometer, Intoximeter and Alcometer, the three most prevalent breath-alcohol testing instruments of the time. Each of these instruments employed wet chemical methods that analyzed breath samples based on chemical interactions between the alcohol molecules and a reagent. They determined that the three instruments could obtain results that were in "close agreement" with direct blood alcohol results.

1952: New York enacted the first Implied Consent Law.

1954: Dr. Robert Borkenstein invented the first truly practical breath-testing instrument, the Breathalyzer. In the mid-1960s, Borkenstein and others utilized the instrument in the important and widely publicized Grand Rapids study, which corroborated Holcomb's study and demonstrated that at a breath alcohol concentration (BrAC) of 0.08 and above the likelihood of causing a motor vehicle crash increases significantly.

1959: The COAD recommended lowering the presumptive level of impairment from 0.150 to 0.100. The National Committee on Uniform Traffic Laws and Ordinances ultimately incorporated this recommendation into the Chemical Tests Section of the Uniform Vehicle Code in 1969.

1960s and 1970s: Inventors modified fuel cells (which were first developed in the 1800s) to identify and quantify breath alcohol. In the 1970s, Mr. Richard Harte invented the first breath alcohol-testing instrument employing infrared spectrometry. The infrared and fuel cell instruments represented a significant step forward in technology. Unlike the original wet-chemical methods, these instruments directly identify and measure the physical properties of alcohol molecules themselves. Virtually all modern instruments rely on one or both of these methods.

1971: The COAD recommended lowering the presumptive level to 0.080. By 1973, every state had enacted Implied Consent Laws. At the time, all breath testing instruments reported their results in terms of blood alcohol concentration, implying a conversion. Jurors often had difficulty understanding the "conversion." (see below for discussions on Henry's Law and the Partition ratio). In the early 1970s, Dr. Kurt Dubowski recommended eliminating the problem by re-defining the presumptions in terms of BrAC. In 1975, the COAD recommended that the Code incorporate Dubowski's suggestion. Most states now define impaired driving offenses in both breath and blood alcohol concentration units.[3]

[3]For a more detailed account of COAD's efforts, See "History of the Committee on Alcohol and Other Drugs," National Safety Council Committee on Alcohol and Other Drugs, http//www.nsc.org/mem/htsd/comitee.htm (1997)

Anatomy of a Breath Sample

To better understand breath-testing devices, one must have a basic understanding of human physiology and alcohol pharmacology. Alcohol typically enters the body through oral ingestion of a beverage containing ethyl alcohol. Alcohol enters the bloodstream through the stomach and small intestine by simple diffusion.

Blood transports the alcohol, which is infinitely water soluble, to the bodily tissues. Veins carry the blood to and through the lungs where the blood becomes oxygenated. Arteries then carry the oxygen-rich blood to the brain and the rest of the body.

Lung tissue is made of air pockets, or alveoli, surrounded by blood-rich membranes. A fraction of the alcohol circulating in the blood crosses the membranes and evaporates into the alveoli. During exhalation, air is forced out of the alveoli and ultimately emerges from the lungs into the person's breath.

During exhalation, air first emerges from the mouth/nasal area, then the throat and upper airway, then the lungs. The highest alcohol concentration in the lungs is found in the deepest portion of the lungs, where the air is in its closest proximity to the blood. When a person exhales completely, the "deep" lung air (also known as the "end expiratory" air) leaves the lungs last. If one were to monitor breath alcohol levels while a person exhaled, the measured level would start at a very low level and rise until it reached a peak or "plateau" as deep lung air is exhaled.

Henry's Law

Henry's Law describes the mechanism of exchange in the lungs, which is influenced by physiological factors. Henry's law directly explains the volume of alcohol in a simulator's vapor. Henry's Law states that in a closed system, at any given temperature, the concentration of a volatile substance in the air above a fluid is proportional to the concentration of the volatile substance in the fluid.

HENRY'S LAW

$$\frac{\text{Wt. of Alcohol per Volume of Air}}{\text{Wt. of Alcohol per Volume of Water}} = K \text{ (a constant)}$$

Partition Ratio

The average temperature of breath as it leaves the mouth is 34 degrees Celsius. At that temperature, research demonstrates that 2,100 milliliters of deep lung air contain about the same quantity of alcohol as one milliliter of arterial blood. Accordingly, breath alcohol instruments calculate the amount of ethanol per 210 liters of air.

Researchers performed extensive tests for decades, comparing blood and breath-alcohol tests. The research demonstrates that breath tests using this ratio report lower alcohol levels than simultaneous venous blood tests for most people. In some cases, however, the breath alcohol levels were higher than the blood alcohol levels. Regardless, when the government charges defendants with having unlawful *breath* alcohol levels per statute, this should not be an issue.

Elements of an Evidential Breath Test Result

All breath-testing programs strive for accuracy, precision, and scientific acceptability. EBTs are fundamentally capable of accurately measuring alcohol in vapor samples. Still, manufacturers and agencies must take several steps to ensure reliability.

Certified Instruments

The Department of Transportation's National Highway Traffic Safety Administration (NHTSA) created national standards for breath testing. NHTSA maintains a list of EBTs and calibration units that conform to its specifications and performance requirements called the Conforming Products List (CPL). NHTSA publishes the CPL, updating it periodically. If properly calibrated and used, listed devices are capable of accurately and reliably measuring breath alcohol. Still, many states impose more rigorous standards than NHTSA.

Administrative Rules
It is essential that all breath-testing programs create and follow scientific protocols. Technicians must keep accurate records documenting the use and testing of every instrument. Because the rules vary from state to state, technicians and prosecutors should consult their respective state's rules to ensure compliance.

Calibration and Maintenance
EBTs are specific to ethyl alcohol. Stated differently, they measure ethyl alcohol to the exclusion of other chemicals or situational artifacts. For example, EBTs can recognize conditions caused by Radio Frequency Interference (RFI) and contamination of the testing environment by fumes or chemicals.

Technicians utilize known standards with different alcohol concentrations to calibrate and regularly test EBTs in accordance with their respective state's administrative rules. The theory underlying this regular testing is simple: EBTs cannot fix themselves; if an EBT works properly before and after a particular breath test, one can be confident that the instrument worked properly at the time of the test.

Technicians typically calibrate and/or test their instruments with wet-bath simulators. Wet-bath simulators consist of an electromechanical device attached to a glass jar or container. Technicians place an aqueous solution containing a known amount of alcohol into the glass container. The simulator heats the solution to, and maintains the solution at, 34^{o} C. Air is passed through an intake port into the solution. An alcohol vapor is created and introduced into the EBT at prescribed times in the testing and/or calibrating routine.

Other technicians use compressed gas (also known as "dry gas") containing known quantities of alcohol vapor to calibrate and/or test the instruments. The compressed gas is a mixture containing a known quantity of ethanol mixed with an inert or non-reactive gas, such as nitrogen, that is contained in a small tank. The concentration of the ethanol is dependent upon the barometric pressure in the atmosphere. Most EBTs are equipped with devices to make corrections for existing barometric pressures. The testing process is simple; the technician simply connects the tank to the EBT. The gas enters the EBT through a compressed gas regulator and hose and is regulated by a solenoid.

The alcohol-containing solutions in liquid solution or compressed gas usually are standardized against reference materials traceable to the National Institute of Standards and Technology (NIST). Technicians using wet-bath simulators should verify that the simulator solution's temperature is appropriate and stable, because variations in the temperature of the simulator can affect the resulting concentration of the alcohol vapor introduced to the EBT. Technicians using compressed gases should determine and correct for variations in barometric pressure; (caused by variations in altitude and weather systems) which can affect the readings. Many EBTs automatically make the necessary corrections.

Purging

EBTs have mechanisms to purge or flush the alcohol-laden sample out of the EBTs' sample chamber and breath hose after each test so that there is no carryover contamination in subsequent tests. After flushing, the instruments run "air blank" or "ambient air" tests to ensure that no alcohol remains and to rule out environmental contamination.

Heating

If condensation occurs during a breath test, it will produce a falsely low reading. Further, the residual alcohol in the condensate may interfere with subsequent breath tests. EBTs avoid this problem by heating the breath hose and sample chamber, thus preventing the subjects' breath from condensing.

Deep Lung Air

As noted above, the alcohol concentration in alveolar or deep lung air (also known as "end-expiratory breath") is most representative of the alcohol content of arterial blood. Breath test operators are trained to know when the EBTs obtain deep lung air samples. Regardless, most manufacturers build one or more sample acceptance features to insure that only the last portion of the breath sample is used. The instruments may monitor the slope during the sample to ensure that a plateau is reached and/or have:

- Minimum sample air volume requirements;
- Minimum pressure requirements;
- Minimum time requirements.

Types of Instruments

Chemical Oxidation and Photometry (Wet-Chemical) Methods
Early researchers conducted breath alcohol tests using chemical oxidation and photometry. For example, in 1927 Bogen conducted blood-breath-urine comparison testing using this method. Bogen collected breath samples in a football-shaped bladder. He then passed the samples through a mixture of dichromate in a sulfuric acid solution. The dichromate-sulfuric acid solution is a distinct yellow color when unreacted, but when alcohol is introduced into the mixture, it oxidizes, chemically altering the dichromate complex and changing the color from yellow to greenish-blue. The more alcohol present, the more oxidation and the greater the corresponding color change. Using this method, Bogen estimated that the alcohol content in two liters of breath is equivalent to that found in one milliliter of blood. Bogen also predicted potential problems due to mouth alcohol (see below for a discussion on mouth alcohol).

In 1931, Harger created the Drunkometer, bringing the wet-chemistry method of analyzing samples of breath for alcohol content to law enforcement. Inventors later developed two other instruments using similar methods, the Alcometer and Intoximeter. All three instruments were portable and capable of being operated by law enforcement officers at roadside. The Drunkometer and the Intoximeter used potassium permanganate instead of dichromate-sulfuric acid; the solution turned from purple to colorless with increasing concentration. These devices estimated end-expiratory air by estimating the concentration of carbon dioxide. The Alcometer device used a different chemical (iodine pentoxide) to oxidize the alcohol and was operationally much less stable, and thus less reliable than the other two first-generation instruments.

In 1954, Borkenstein developed the Breathalyzer instrument, arguably the greatest single improvement to breath-testing technology to date.

This device was based on a wet-chemical analysis method, but greatly improved upon the then-existing methods. Like the other three first-generation instruments, the Breathalyzer was portable and designed for roadside use by a trained operator. The Breathalyzer used Bogen's method of oxidation of alcohol by a dichromate-sulfuric acid solution; however, Borkenstein assured the reliability of results by standardizing the reagents' size and volume in prepackaged, sealed ampoules. Additionally, he set the reaction time and created a system to interpret results by standardized colorimetry. Early models required the operator to manually set a baseline, therefore causing the Breathalyzer's detractors to label them "Dial-A-Drunk." However, the Breathalyzer yielded accurate and reliable results. Regardless, the mere possibility of manipulation and the existence of alleged anecdotal incidents of impropriety created an element of doubt.

Infrared Instruments

Infrared instruments are the most commonly used breath-testing instruments because of their stability, reliability, and automation. These instruments utilize an analytical process known as infrared spectroscopy (IR).

The Beer-Lambert Law of Absorption provides the theoretical basis for IR breath testing. Molecules absorb electromagnetic radiation at certain specific, unique wavelengths. Thus, it may be said that each molecule has its own "infrared fingerprint." Ethyl alcohol absorbs radiation at wavelengths of approximately 3.00, 3.39, 7.25, 9.18, 9.50 and 11.5 microns. No other compound absorbs radiation at all of those wavelengths exclusively.

Infrared instruments measure energy entering a vapor-filled cavity or sample chamber inside the instrument. When the IR energy beam emerges from the sample chamber, the instrument measures an energy loss in the affected IR wavelength regions if alcohol is present. The more alcohol the sample contains, the greater the degree of absorption and the more IR energy loss.

One of the principal advantages of using an infrared analyzer is that it can measure sample alcohol levels continuously and immediately in real time while the exhalation is in progress. The instrument correlates the response of the detector, i.e. the breath alcohol level, to a time measurement in order to measure the slope of the resulting curve. This "slope detection" technology allows a sample to be aborted if the profile shows the slope of the breath alcohol curve to be different from that expected for an acceptable sample, possibly indicating the presence of residual mouth alcohol. When the slope's peak is attained and sustained, the technician may be reasonably assured that he or she obtained deep lung air.

Fuel Cell Instruments

Fuel cell instruments operate on the principle of electrochemical oxidation. Fuel cell technology is not new or novel; the effect was discovered in the 1800s. There was no practical application of fuel cells at that time because of high cost and technological problems. In the 1960s, researchers at the University of Vienna demonstrated a fuel cell specific for alcohol. Modern fuel cell instruments determine alcohol concentration by measuring the electrical reaction caused by alcohol oxidation.

Fuel cell technology is particularly suitable for portable screening devices, due to the small size of the cells and the low power requirements of this technology. In recent years, fuel cell detector and breath sampling improvements have made it possible to produce analyzers that meet NHTSA specifications for EBTs. "In its simplest form, the alcohol fuel cell consists of a porous, chemically inert layer coated on both sides with finely divided platinum oxide (called platinum black). The manufacturer impregnates the porous layer with an acidic electrolyte solution, and applies platinum wire electrical connections to the platinum black surfaces. The manufacturer mounts the entire assembly in a case, which also includes a gas inlet that allows a breath sample to be introduced."[4]

Fuel cell instruments do not react to acetone, a potentially interfering substance, but may react to alcohols other than ethyl alcohol, for example, isopropyl (rubbing) alcohol, methyl (wood) alcohol, and others (see below for a discussion on interfering substances). The probability that these more highly toxic alcohols exist in any measurable concentration in

[4] http://www.intox.com/fuel_cell_explanation.asp.

human breath is exceptionally low, and even if present, the effect produced would be one of greater intoxication than that produced by ethyl alcohol. Therefore, there is no significant chance for chemical interference in fuel cell instruments.

Dual Detector

At least one instrument employs both an infrared and a fuel cell detector in the same unit. The instrument can be programmed to use a combination of detector results. The infrared (IR) detector can be programmed to verify the evidential results produced from the fuel cell detector, or vice versa. Any significant discrepancy between the two results invalidates the tests. Dual detector systems are advantageous because different methods potentially are susceptible to different types of interferents.

Other Technologies

Chromatography is a method for separating a mixture's components. Chromatography is widely used for *blood* alcohol testing. However, it is not used for breath testing.

Challenges to Breath Alcohol Results

Defendants, facing criminal adjudication and increased insurance fees and costs, frequently litigate their DUI cases. Per se laws focus attention on chemical analysis rather than psychophysical evidence of impairment. Defendants who successfully challenge their breath results will dramatically improve their chances of acquittal. Accordingly, defense attorneys are becoming more and more creative in their attacks.

Many claims are easy to refute as illustrated below. As a general rule, when a technician tests an EBT with several different "known" solutions in accordance with the administrative rules and the instrument records appropriate results, the technician can be confident in the instrument and the solutions used to test it.

Practice Tip
Many states require defendants to provide two breath samples within 0.020 of each other. It is very unlikely that an instrument would record two samples within 0.020 of each other if the operator or instrument conducted the test improperly.

The following are some of the most common issues involving EBT results. The list is not exhaustive. Additionally, creative defense lawyers frequently re-characterize them in alternative ways.

Claim: The Operator or Maintenance Officer did not Comply with All of the Rules.

Response: Virtually every state has judicially recognized rules and procedures to ensure the accuracy and reliability of breath testing. Accordingly, defendants focus their attacks on any violations of the rules that may affect the accuracy and reliability of their breath test results. Typically, they argue that judges should suppress their breath test results because the operator or maintenance officer ignored, skipped, or otherwise violated an administrative rule.

In virtually all states, breath tests are admissible if administered in *substantial compliance* with the rules. Accordingly, judges should admit breath test results unless the alleged deviation(s) raise a substantial and legitimate question about the accuracy and reliability of the tests that prejudices the defense. Prosecutors must assess defense claims on a case-by-case basis. They should familiarize themselves with their own jurisdiction's administrative codes, agency checklists, and training procedures. They should understand why the individual rules were instituted and determine whether the alleged deficiency (ies) renders the test results unreliable. Claims involving minor deviations or speculative issues go to the weight, rather than the admissibility, of the evidence.

Claim: Residual Mouth Alcohol Affected the Reading.

Response: Undetected, raw, unabsorbed alcohol in the mouth may falsely elevate the results of a breath test. Various sources may contribute to mouth alcohol:

- A substance ingested prior to the breath test; or
- A substance regurgitated or eructated (burped) from the stomach or gastroesophogeal reflux

Alcohol evaporates very quickly. Researchers have examined the persistence of alcohol vapors in the mouth after ingestion of many types of food, alcoholic beverages, gum, oral care strips, asthma inhalers, tobacco, and other substances. They have even looked at subjects with dentures and mouth jewelry. They found that if a person refrains from eating anything or regurgitating any fluids for 15 minutes, there will be no residual alcohol in his or her mouth. Regardless, it is unlikely that belching, whether detected or not, will bias a test result, because that portion of the exhaled breath, typically an earlier fraction of the exhaled stream, will pass through the sample chamber and be replaced by the last portion of breath exiting the lungs.

Accordingly, all breath-testing programs require the operator or other trained individual to "continuously" observe the subject for 15 to 20 minutes before a breath test (the exact amount of time varies among the jurisdictions). The rules typically require reasonable observation. They do not require the observer to stare unblinkingly at the subject under bright lights to the exclusion of all other activities. They simply require the observer to watch the subject to a degree that allows the observer to reasonably conclude that the subject did not ingest or regurgitate any substances. In order to avoid confusion, operators should record the time they begin their observation.

Some manufacturers equip their instruments with "mouth alcohol detectors" or "slope detectors" to identify mouth alcohol. During a breath test, these instruments measure alcohol content continuously. Mouth alcohol creates a different pattern than a normal breath sample. If a subject has no mouth alcohol, the instrument will read a continuous, though not linear, rise in breath alcohol level until it reaches a plateau. If mouth alcohol is present, there may be a significant and sudden drop. A slope detector identifies and reports this drop as mouth alcohol. The slope detectors are useful but not perfect.

Other potential safeguards or factors include:
- Inspecting the subject's mouth prior to testing;
- Using a new mouthpiece for each breath test, even for the same subject;
- Obtaining multiple breath samples because alcohol dissipates extremely rapidly;
- It is almost impossible to obtain two breath samples two to 10 minutes apart within 0.02 of one another if one (or both) is contaminated by mouth alcohol.

Claim: Interfering Substances Affected the Reading.

Response: Some substances are so similar to ethyl alcohol that early single-wavelength infrared EBTs had difficulty distinguishing them or were unable to distinguish them. Theoretically, these "interfering substances" could inflate breath test results. This is less of a problem than it would seem. There are only a few volatile substances that can be found in the breath of a living, breathing person other than alcohol. Furthermore, when alcohol is present in the breath, it far exceeds in concentration any other volatile components of the breath sample.

In fact, only one potentially interfering substance has been shown to exist in measurable concentrations in the human body over time: acetone. The body produces acetone as a byproduct of incomplete digestion in a very few individuals such as diabetics whose insulin levels are not controlled. If a person is diabetic or fasting, the officer and prosecutor should obtain as much information as possible about the person's condition or diet. Additionally, people, most notably painters, may be exposed to acetone at work. If a person is exposed to acetone, officers and prosecutors should learn as much as possible about:
- Duration of exposure
- Environment of exposure
- Use of respiratory protective equipment
- Nature of material
- Time between last exposure and breath alcohol test
- Observation of arresting officer

As early as the late 1970s, manufacturers recognized and resolved the issue by modifying their instruments to measure IR at two different wavelengths. Alcohol creates a unique ratio between the wavelengths. The modern instruments establish and measure the ratio to verify that they measure alcohol only. Over time, manufacturers added additional wavelengths to increase the instruments' specificity even more.

Substances other than alcohol do not affect fuel-cell instruments. Thus, dual technology EBTs are specific for alcohol on both the IR and fuel cell analytical systems.

Case Examples[5]

Police arrested two defendants for DUI in separate incidents in the United Kingdom. Both defendants painted for several hours prior to their arrests. They claimed that paint solvents inflated their breath alcohol readings and agreed to participate in an experiment to prove it. They painted in enclosed rooms for as long as they could, inhaling copious amounts of paint fumes. The paints in both experiments contained toluene and xylene. One also contained methanol. Eventually, they asked to stop painting because "[t]heir eyes were watering and suffering from severe irritation; they were coughing regularly and complaining of sore mouths and throats." Both defendants provided breath samples. The first defendant blew a 0.005 immediately after stopping; the second blew a 0.009. Thirty minutes later, the first defendant blew 0.000 and the second defendant blew .001. The experimenter concluded, "[t]hese results strongly support the contention that misleading Intoximeter 3000 results do not occur due to long term retention of these solvents in the body arising from working in polluted atmospheres. They confirm that recovery from the inhalation of solvents is normally rapid and could only be expected to lead to very slightly inflated breath alcohol levels on evidential breath tests carried out less than 30 minutes after exposure to the solvents has ceased."

5 *See* R.C. Denney, "Solvent inhalation and 'apparent' alcohol studies on the Lion Intoximeter 3000," 30 J. FOR. SCI. SOC. 357 (1990).

Claim: Radio Frequency Interference (RFI) Inflated the Reading.

Response: All radio transmitters, including cellular phones and police radios, emit radio waves. Radio transmitters reportedly interfered with early EBTs that had no or insufficient shielding. Modern EBTs are protected from RFI by metal covers and additional shielding around power supplies and other openings in the instruments. Some EBTs have detection systems designed to terminate a test in progress if the instrument detects RFI. CMI, the manufacturer of the Intoxilyzer™ instruments, commissioned a comprehensive study for Radiated Radio Frequency Susceptibility by an independent laboratory in 1983. The researchers measured the Intoxilyzer™ under various RFI conditions with different field strengths and distances and determined that the instrument functioned properly.

Claim: Environmental Influences Contaminated the Reading.

Response: External alcohol or other substances such as solvents, cleaning agents, or exhaust fumes, allegedly may interfere with breath tests, causing the instruments to artificially inflate test results. Modern instruments eliminate this concern by automatically testing the room air in so-called "ambient air" or "air blank" tests between breath tests or simulator and alcohol tests. A 0.000 demonstrates that the air is "clean" and that the sample chamber in the instrument is fully purged of alcohol vapors. Modern EBTs have mechanisms designed to report contaminants over a certain threshold and alert the EBT operator of the problem.

A mouthpiece contaminated by alcohol from prior use theoretically may also create an unreliable result. While this is very unlikely, breath test operators can eliminate the risk altogether by using a new mouthpiece for every subject.

Claim: The Breath Test Operator Erred or Manipulated the Results.

Response: Modern EBTs automatically run diagnostic tests during each breath test. Although an operator initiates each test, each instrument's software directs the process. If an operator fails to instruct a subject properly or to provide the subject a sufficient opportunity for a complete test, the operator may obtain an artificially low reading. However, the operator cannot manipulate the test to achieve a reading higher than a subject's true BrAC.

Claim: The Wet Bath Simulator Used to Test the Instrument was not Working Properly.

Response: Simulator solutions in many jurisdictions are stored in polyethylene (plastic) containers when they are not in use. Defense experts may argue that volatile solutions such as alcohol should be stored only in glass containers at 4° C. However, while storage in glass containers may be appropriate for trace analysis, it is unnecessary for alcohol simulator solutions. Regardless, laboratories and police agencies can eliminate the issue altogether by creating and following clearly written policies regarding the preparation, storage, distribution and use of simulator solutions.

Defense attorneys sometimes question the accuracy of the thermometers that measure the temperature of the simulator solution during use with an EBT. The temperature of simulator solutions is critical to ensure the appropriate application of Henry's Law. Every thermometer, like all other analytical instruments, has an inherent uncertainty. This uncertainty does not necessarily affect the accuracy of the breath alcohol result; the issue may be technical compliance with a foundational evidential requirement.

Challenges can also arise where the forensic protocols for establishing traceability do not conform to NISTs. Agencies and inspectors may avoid this concern by establishing a protocol for the periodic testing and documentation of simulator thermometers using a traceable reference thermometer.

Regardless of the challenge, toxicologists can be confident in both their simulators and their instruments if they all appear to be in working order, particularly if they test multiple instruments with the same simulators. It is highly unlikely that multiple instruments would have equal but opposite deficiencies to a simulator.

Conclusion

During the past few decades, EBT manufacturers and researchers systematically identified several external conditions that could affect the accuracy of breath analyses and modified the breath testing instruments to compensate for them. When properly calibrated, maintained and operated, EBTs are accurate, reliable and dependable.

APPENDIX A

Detection Technology Employed in Evidential Breath Alcohol Testing Instruments

Primary Detection Principle	EBT Instrument
Infrared spectrometry	BAC DataMaster BAC DataMaster cdm Intoxilyzer 1400 Intoxilyzer 5000, 5000 EN Intoxilyzer 8000 Intoxilyzer 4011A* Intoxilyzer 4011 AS-A*
Electrochemical oxidation/fuel cell	Intox EC/IR RBT IV, RBT IV XL
Dual detector (infrared/fuel cell)	Alcotest 7110 MKIII-C
Alcoh-Analyzer 2100*	

**Indicates instruments that are no longer manufactured*

APPENDIX B

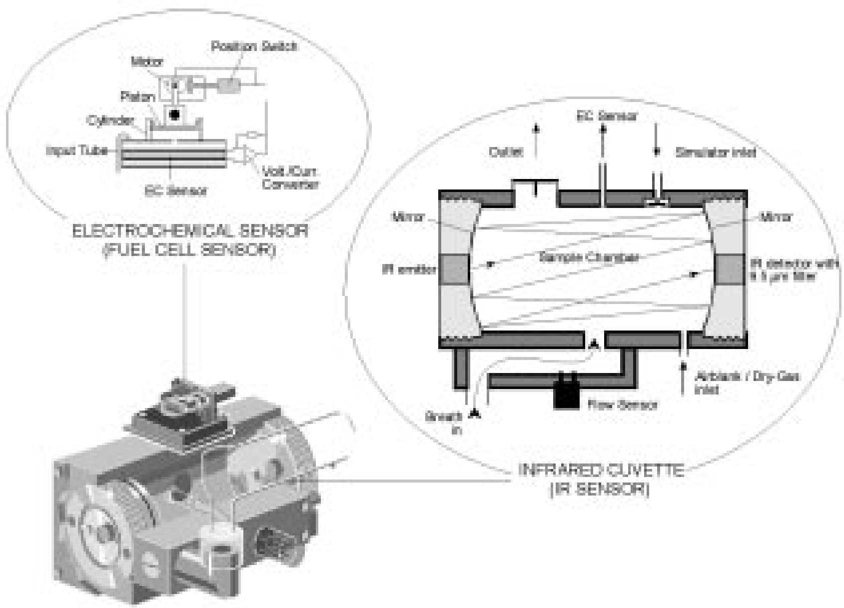
Characteristics of Selected EBT Instruments

Instrument Name: **Alcotest® 7110 MK III C**
Manufacturer: Dräger Safety, Inc.
Features:

- The Alcotest 7110 MKIII C is equipped with two independent and different sensors to enable the breath alcohol measurement: Infrared Absorption System (IR) and Fuel Cell (EC).
- Independent Dual Sensoric (IR and EC). The instrument can be programmed to use any combination of detector results. The infrared sensor may be used as the primary result with independent corroboration from the fuel cell system, for example.
- True air blank analysis
- Infrared absorbtion at 9.5 μm, rapid recovery fuel cell
- Ethanol specificity
- Breath temperature analysis
- Automatic dry-gas measurement
- 12 VDC or AC operation without additional equipment
- External, flexible breath hose (heat controlled) with disposable mouthpieces

Operation:
Test sequence initiated through keyboard command or pressing button on keyboard. Audible prompts and visual cues from keyboard prompt operator and inform operator of problems with instrument. Air blank analysis performed before and after each subject or control test, using the fuel cell detector. Breath temperature readings may be corrected automatically to 34°C.

Figure 1: Alcotest® 7110 MK III C



Instrument Name: **DataMaster®**
Manufacturer: National Patent Analytical Systems, Inc.
Features:

- Thermo-electrically lead-selenide infrared detector cooled to 0° C for detection of much smaller signals
- 1.1 Meter folded optical path for maximum energy absorption
- 50cc sample cell for permitting the DataMaster to be highly specific for only ethanol (virtually excluding other alcohols and potentially interfering compounds)
- Exceptionally narrow bandwidth optical filters allow absorption at 3.37 and 3.44 µm, with optional "Delta" filter at 3.50 µm
- Grey Body infrared energy source
- Thermistor flow detection
- Complete automation of programmed test sequences
- Option for remote operation through host computer
- External, heated breath tube with disposable mouthpieces
- Quartz plate of known absorbance is used as an internal calibration check

Operation:
Test initiated by pressing button on keypad. Audible prompts and visual cues from keyboard prompt operator and inform operator of problems with instrument. Room air drawn into instrument sets the analytical baseline before each test. Air blank analysis performed before and after each subject or control test.

Figure 2: DataMaster cdm

Instrument Name: **EC/IR®**
Manufacturer: Intoximeters, Inc.
Features:

- Reliable, rapid recovery fuel cell analysis combined with real time infrared sampling system for slope detection
- Two narrow bandpass filters of 3.45 μm and one of 4.26 μm, used for carbon dioxide
- Fully automated test procedure
- Dual microprocessors, one for controlling all analytical functions and one for user interaction
- Advanced self-diagnostic capabilities
- Automatic accuracy checks and calibration
- Heated external breath tube with disposable mouthpieces

Operation: Tests are initiated through keyboard commands. The fuel cell is zeroed electronically and ambient air is tested before subject testing. Visual cues from keyboard prompt operator through test sequence. The timing of detection of carbon dioxide in breath compared to alcohol is used to determine the presence of mouth alcohol.

Figure 3: EC/IR®

Instrument Name: **Intoxilyzer®**
Manufacturer: CMI, Inc.
Features:

- Cooled Detector: Single stage, thermoelectrically-cooled lead solenoid detector with an integral thermistor for temperature regulation
- Light Path: Path length is 11.4 inches (28.9 cm)
- Absorption Wavelength: Narrow passband IR filters are used to measure infrared absorption at specific wavelengths yielding reference, alcohol and interferent detection. Three filters (3.8 µm, 3.47 µm and 3.38 µm) in rotating chopper wheel. The 768 Series and EN instruments have two additional filters at 3.36 µm and 3.52 µm.
- Light Source: Tungsten filament in halogen gas enclosed by a clear quartz envelope. Life expectancy is more than 10,000 hours
- Complete automation of preprogrammed test sequences
- External, heated breath tube with disposable mouthpieces

Operation:
Test initiated by pressing button on keypad. Audible prompts and visual cues from keyboard prompt operator and inform operator of problems with instrument. Room air drawn into instrument sets the analytical baseline before each test. Failure of any portion of the internal checkwill be indicated and the test will be aborted. Air blank analysis performed before and after each subject or control test.

Figure 4: Intoxilyzer EN®

GLOSSARY

ABSORPTION (in the body) — the process by which a drug enters the blood circulation after ingestion or other extra-vascular route.

ACCURACY — closeness of a test result to the true value of the item being measured.

ACETONE — a volatile, fragrant flammable liquid ketone used chiefly as a solvent and in organic synthesis and found in abnormal quantities in diabetic urine. Chemical formula C_3H_6O.

ALVEOLI — cells within the lungs where membranes enfold air pockets in such a way that gases may be freely exchanged between blood and the air across the membrane.

AMBIENT — a condition existing under ordinary conditions or present on all sides.

AMPOULE — a hermetically sealed glass vessel containing a chemical preparation.

AQUEOUS — dissolved in water.

ARTIFACTS — an unanticipated or unexpected result of a test.

BANDPASS — frequencies within a selected band.

CALIBRATION — a process of adjusting a measuring device to a standard so as to ascertain the correction factors required for accurate measurement.

CHROMATOGRAPHY — a process in which a chemical mixture is carried over a receptive, stationary substrate for the purpose of separating the components of the mixture on the basis of size or other physical property.

COMPOUND — a substance made of two or more pure substances.

CONTROL — preparations containing substance of interest used to document accuracy, precision and lack of bias in the testing procedure.

ELECTRODE — a conductor used to establish electrical contact with a nonmetallic part of a circuit.

ETHYL ALCOHOL — the second smallest alcohol next to methyl alcohol, it is a clear, colorless flammable liquid with a burning taste.

FUEL CELL — a device that continuously changes the chemical energy of a fuel and an oxidant into energy.

GASTROESOPHOGEAL REFLUX — a condition arising from the dysfunction of the lower esophageal sphincter causing stomach contents to leak into the esophagus.

INERT — not chemically reactive.

INTERFERANT — a chemical substance other than the substance of interest that may create a false positive or elevated reading.

INFRARED SPECTROSCOPY — a technique for determining the identity of a substance and the quantity of the substance by exposing the substance to infrared energy and analyzing the nature and amount of absorption by the substance.

OXIDATION — a chemical reaction where electrons are transferred from one atom or molecule to another.

PHARMOKINETICS — the study of drugs, absorption, distribution and elimination in and from the body.

PHARMODYNAMICS — the study of the effect of the drug on the body.

PHYSIOLOGY — with the study of the body's organs and systems.

PRECISION — the closeness of a group of measurements to each other. Also known or described as reproducibility. Precision typically is provided in terms of standard deviation.

RADIO FREQUENCY INTERFERENCE (RFI) — electromagnetic radiation that is emitted by electrical circuits carrying rapidly changing signals that may cause unwanted signals (interference or noise) to be induced in other circuits.

REAGENT — a substance used in a chemical reaction.

STANDARD — preparations of known concentration of the substance of interest prepared from material traceable to a certified source used for instrument calibration and to verify calibration.

THERMISTOR — an electrical resistor whose properties vary with temperature.

WET-BATH SIMULATOR — a device used for calibrating breath testing instruments consisting of a container of alcohol and water solution, a heater and method for stabilizing temperature and ports to vent the heated alcohol-rich vapor.

VOLATILE — a property of a substance to change to a vapor phase from a liquid phase at low temperatures.

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American Prosecutors Research Institute
99 Canal Center Plaza, Suite 510
Alexandria, Virginia 22314
Phone: (703) 549-4253
Fax: (703) 836-3195
http://www.ndaa-apri.org

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