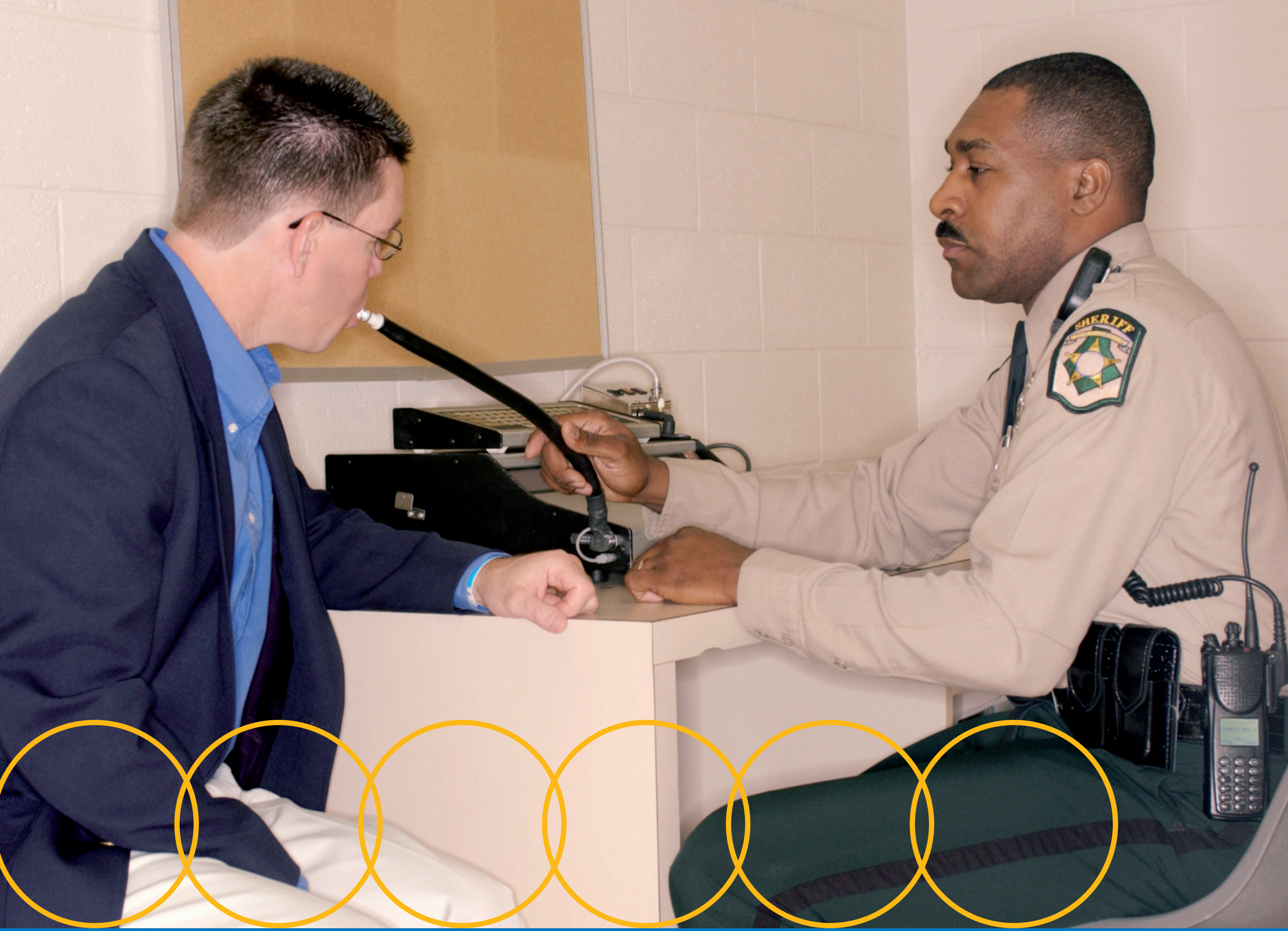

Breath Testing
FOR PROSECUTORS

JANUARY 2025

NTLC NATIONAL TRAFFIC LAW CENTER NDAA

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National District Attorneys Association

NTLC
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NDAA

National Traffic Law Center

The National District Attorneys Association's National Traffic Law Center (NTLC) is a resource designed to benefit prosecutors, law enforcement, judges, and criminal justice professionals. The mission of NTLC is to improve the quality of justice in traffic safety adjudications by increasing the awareness of highway safety issues through the compilation, creation and dissemination of legal and technical information and by providing training and reference services.

When prosecutors deal with challenges to the use of breath test instruments, blood tests, horizontal gaze nystagmus, crash reconstruction, and other evidence, the NTLC can assist with technical and case law research. Likewise, when faced with inquiries from traffic safety professionals about getting impaired drivers off the road, the NTLC can provide research concerning the effectiveness of administrative license revocation, ignition interlock systems, sobriety checkpoints and much more.

The NTLC has a clearinghouse of resources including case law, research studies, training materials, trial documents, and information regarding crash reconstruction, toxicology, drug recognition, and many other topics. The information catalogued by the Center covers a wide range of topics with emphasis on impaired driving and vehicular homicide issues.

The professional staff at the NTLC includes experienced trial attorneys and research staff. Assistance is specifically provided in all areas of trial preparation, including methods to counter specific defenses. The NTLC facilitates the direct exchange of information among prosecutors, judges and other criminal justice professionals in the field.

NTLC is a program of the National District Attorneys Association. NDAA's mission is to be the voice of America's prosecutors and to support their efforts to protect the rights and safety of the people.

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Acknowledgements

The original edition of *Breath Testing for Prosecutors* monograph was first published in December 2004 with a charitable contribution from the Anheuser-Busch Foundation in St. Louis, Missouri. It was designed to educate prosecutors about the basics of breath testing theories and procedures. It was the result of the dedicated work of author, **Jeanne Swartz**, a criminalist then-assigned to oversee the breath alcohol-testing program with the Alaska Department of Public Safety. The following traffic safety professionals (and the positions they held at the time of publication) also contributed to the creation of the original version:

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Dr. Barry Logan, Washington State Patrol, Forensic Laboratory Services Bureau Director

Ms. June Stein, Kenai Borough (AK) District Attorney

Mr. Stephen Talpins, National Traffic Law Center

Mr. Chip Walls, University of Miami Forensic Toxicology Department Director

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Ben Vetter, Director of the Breath Alcohol Section/Montana Forensic Science Division

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Preface

Impaired drivers are a scourge on society. In 2003, more than 17,000 people died in alcohol-related car crashes, or an average of one alcohol-related fatality every 31 minutes, and an additional quarter million people were injured.[1] With law enforcement officers using breath-testing instruments to investigate the vast majority of impaired driving cases, prosecutors needed to understand the basics of breath alcohol testing. Thus, *Breath Testing for Prosecutors* was first published in 2004, and attempted to provide prosecutors with a basic understanding of the breath instruments used, the elements of a breath test result, and answers to some common challenges to breath test results.

In 2022, there were over 13,000 traffic crash fatalities in which at least one driver was alcohol-impaired, or an average of one alcohol-related fatality every 39 minutes.[2] While this represents an improvement over twenty years, it is still an unacceptable number as each death was preventable. Numeric values cannot be placed on the pain and suffering impaired drivers cause.

The National Traffic Law Center's Monograph Series has been relied upon by prosecutors for almost two decades. Covering a wide range of topics, from crash reconstruction to the admissibility of horizontal gaze nystagmus evidence, these monographs are a valuable resource to the legal community. This second edition of *Breath Testing for Prosecutors*[3] provides necessary updates for a new generation of prosecutors. Today's prosecutor handles a larger caseload and faces a more experienced defense bar specializing in challenges to breath test evidence. Breath testing remains a reliable and cost-effective means of evidence collection in an impaired driving investigation. With the increased prevalence of drug-impaired driving, breath testing may also serve as the first step in the process to secure blood evidence for some suspects. This edition addresses these issues and more with an eye toward saving lives on America's roadways.

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1 National Center for Statistics and Analysis. *Alcohol-impaired driving: 2003 data* (Traffic Safety Facts. Report DOT HS 809 761). National Highway Traffic Safety Administration.

2 2022 is the most recent year for which data is available; *see* National Center for Statistics and Analysis. (2024, May). *Alcohol-impaired driving: 2022 data* (Traffic Safety Facts. Report No. DOT HS 813 578). National Highway Traffic Safety Administration.

3 Although there is ongoing research to detect THC, the psychoactive ingredient of Cannabis, in breath, the focus of this monograph remains breath alcohol testing.

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 laws prohibiting Driving Under the Influence (DUI) of alcohol and Driving While Impaired (or Intoxicated) (DWI). In rural areas, law enforcement officers encountered problems contacting physicians and collecting blood samples for forensic analysis within a reasonable amount of time after stopping suspects. Law enforcement 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 content.

Today, law enforcement officers and prosecutors around the world rely on breath alcohol[4] 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 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 can produce reliable results. EBTs are held to much higher administrative standards than screening devices, however, and are subjected to strict administrative controls and safeguards, including regular inspections and accuracy checks. This monograph addresses EBTs only.

[4] In this monograph, the word “alcohol” refers to alcoholic beverages meant for human consumption. In science, the word “alcohol” is not that specific. While the general public relates alcohol to the drinking kind, there are many others that fall under the category of alcohol. Ethanol is the type of alcohol in alcoholic beverages. In this monograph, use of the word “alcohol” refers to ethanol unless otherwise noted.

Breath Alcohol Testing

The Historical Development of Breath Alcohol Testing

In the early 1930s, impaired driving became a national issue. The legal and scientific communities, however, were ill equipped to address the burgeoning problem. Neither scientists nor legal scholars could define "impairment" or "under the influence." Further, even in educated circles, conventional wisdom dictated 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. Each of these methods, however, 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 these issues: breath-alcohol testing and "per se" laws. A brief history of these developments follows:[5]

1927: Dr. Emil Bogen reported measuring blood alcohol concentration (BAC) by analyzing a person's breath.[6] 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 the risk of causing a crash[7] increased six times at a blood alcohol concentration of 1 part of alcohol to 1,000 parts of blood and 25 times at 1.5 parts of alcohol to 1,000 parts of blood.[8]

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[5] *See* A.W. Jones, "Fifty Years On—Looking Back at Developments on Methods of Blood- and Breath-Alcohol Analysis," for a detailed history of breath testing.

[6] Bogen, E. "The Diagnosis of Drunkenness—A Quantitative Study of Acute Alcoholic Intoxication," *California and Western Medicine*, June 1927.

[7] The word "accident" is used in the underlying study. Today, the word "accident" refers to preventable crimes whereas traffic safety professionals prefer to refer to them as the traumatic "crash" or "collision" they are when an impaired driver is responsible.

[8] *See* R. L. Holcomb, "Alcohol in Relation to Traffic Accidents," *JAMA*. 1938; 111(12):1076–1085.

1938: The National Safety Council's Committee on Alcohol and Other Drugs (CAOD) (formally known as the Committee on Tests for Intoxication and known today as the Alcohol, Drugs, and Impairment Division or ADID) collaborated with the American Medical Association's Committee to Study Problems of Motor Vehicle Accidents[9] 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.

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 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,[10]

[9] The word "accident" is used in the title of the study. Today, the word "accident" refers to preventable crimes whereas traffic safety professionals prefer to refer to them as the traumatic "crash" or "collision" they are when an impaired driver is responsible.

[10] Borkenstein RF, Crowther RF, Shumate RP. The role of the drinking driver in traffic accidents (the Grand Rapids study). *Blutalkohol* 1974; 11(Suppl):1–131.

which corroborated Holcomb's study[11] and demonstrated that at a breath alcohol concentration (BrAC) of 0.08 g/210L and above the likelihood of causing a motor vehicle crash increases significantly.

1959: The CAOD recommended lowering the presumptive level of impairment from 0.150 g/210L to 0.100 g/210L. 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 methods.

1971: The CAOD recommended lowering the presumptive level to 0.080 g/210L. 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 redefining the presumptions in terms of BrAC. In 1975, the CAOD recommended that the Code incorporate Dubowski's suggestion. Most states now define impaired driving offenses in both breath and blood alcohol concentration units.[12]

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 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 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.

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11 *See* R. L. Holcomb, "Alcohol in Relation to Traffic Accidents," *JAMA*. 1938; 111(12):1076–1085.

12 For a more detailed account of CAOD's efforts, *see* "History of the Committee on Alcohol and Other Drugs," National Safety Council Committee on Alcohol and Other Drugs, (1997).

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 concentration while a person exhaled, the measured content would start at a very low concentration 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° 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 content than simultaneous venous blood tests for most people. In some cases, however, the breath alcohol content was higher than the blood alcohol concentrations. Regardless, when a prosecutor charges a defendant with having unlawful *breath* alcohol concentration per statute, this should not be an issue.

EBTs are fundamentally capable of accurately measuring alcohol in vapor samples.

Components 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 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).[13] NHTSA publishes the CPL, updating it periodically. If properly calibrated and used, listed devices are capable of accurately and reliably measuring breath alcohol. Even so, many states impose more rigorous standards than NHTSA.

ADMINISTRATIVE RULES

It is essential that a breath testing program creates and follows scientific protocols. A technician 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.

It is essential that a breath testing program creates and follows scientific protocols.

CALIBRATION AND MAINTENANCE

EBTs strive to be 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 the instrument worked properly at the time of the test.

A technician typically calibrates and/or tests their instruments with wet bath simulators. Wet bath simulators consist of an electromechanical device attached to a glass jar or container. A technician places 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°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 sequence.

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[13] *See* United States Department of Transportation, National Highway Traffic Safety Administration, Highway Safety Programs; Conforming Products List of Evidential Breath Alcohol Measurement Devices, 82 Fed. Reg. 50940 (November 2, 2017) (updating the Conforming Products List published in the *Federal Register* on June 14, 2012, 77 Fed. Reg. 48705, for the instruments that conform to the Model Specifications for Evidential Breath Alcohol Measurement Devices dated September 17, 1993, 58 FR 48705), available at www.nhtsa.gov/drunk-driving/alcohol-measurement-devices, last accessed August 27, 2024.

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 alcohol mixed with an inert or non-reactive gas, such as nitrogen, contained in a small tank. The concentration of alcohol is dependent upon the barometric pressure in the atmosphere. Most EBTs are equipped with a device 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). A technician using a wet bath simulator should verify 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. A technician 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.

Some EBTs may utilize an Internal Standards program to also help ensure accuracy and reliability with every subject test. Internal Standards are basically a simulated alcohol standard the technician sets up as part of the calibration procedure. The Internal Standards can be run quickly with every subject test without the use of any external alcohol standard or equipment (*e.g.*, simulator or dry gas bottle) or in conjunction with an external standard.

PURGING/AIR BLANK

Prior to running any test, most EBTs will run an "Air Blank." This uses a mechanical pump to pull in ambient air and verify there are no interfering substances or ethyl alcohol present. After a sample is taken, EBTs have mechanisms to purge or flush the alcohol-laden sample out of the EBTs' sample chamber and breath hose after each test so there is no carryover contamination in subsequent tests.

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 subject's 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. Additionally, most manufacturers build one or more sample acceptance features to ensure only the last portion of the breath sample is used.

The instruments may monitor the slope during the sample to ensure 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 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[14] 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." Ethanol absorbs radiation at wavelengths of approximately 3.00, 3.39, 7.25, 9.18, 9.50 and 11.5 microns.[15] 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.

Infrared instruments are the most commonly used breath testing instruments because of their stability, reliability, and automation.

One of the principal advantages of using an infrared analyzer is it can measure sample alcohol concentrations 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 concentration, 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 he or she obtained deep lung air.

FUEL CELL INSTRUMENTS

A fuel cell instrument operates 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, however, 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.

14 For additional information on this equation, *see*, for example, scienceinfo.com/beer-lambert-law-statement/, last accessed June 18, 2024.

15 *See*, for example, Hegde, N. "A Review on Alcohol Sensors." *See also* the National Institute of Standards and Technology webpage on Ethanol at webbook.nist.gov/cgi/cbook.cgi?ID=C64175&Type=IR-SPEC&Index=2, last accessed on September 4, 2024.

Given the small size of the cells and the low power requirements of this technology, fuel cell technology is particularly suitable for portable screening devices. In recent years, fuel cell detector and breath sampling improvements have made it possible to produce analyzers meeting 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."[16]

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 these more highly toxic alcohols exist in any measurable concentration in 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 a fuel cell instrument.

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 are potentially susceptible to different types of interferents.

Some newer EBTs are also using multiple IR filters and can produce multiple results from a single breath sample. While this is not a true dual detector system, it still creates much more specificity for ethanol when the results of the reporting filters correlate within specifications (*i.e.*, all results are within 0.020 g/210L of each other or similar requirements).

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.

16 Intoximeters, *Fuel Cell White Paper*, available at www.intox.com/fuel-cell-white-paper/, last accessed June 14, 2024.

Quality Management, Quality Control, and Quality Assurance

The terms quality control (QC) and quality assurance (QA) are often used interchangeably. They are interrelated and very much a part of ensuring the quality of a laboratory, a breath alcohol program, or a single test result but they are also very different. A third term which is also used, Quality Management or Quality Management System (QMS), includes all activities covering the quality of a program and includes QA and QC. Quality assurance helps to outline the requirements of the QMS. Quality control, a subset of quality assurance, is a process or procedure intended to ensure a product, service, or methodology adheres to defined criteria.

ISO 9000:2015[17] includes the following definitions for QA and QC:

QA—part of quality management focused on providing confidence that quality requirements will be fulfilled.

QC—part of quality management focused on fulfilling quality requirements.

To think about it another way, quality assurance is a process implemented to define requirements, define quality, validate and implement methodologies, and define the criteria surrounding the performance of an instrument or method. Quality control is the evaluation of the system, instrument, or method to determine if it is within the defined criteria.

Is it QA or is it QC?

When evaluating certain parameters within a breath alcohol program, it may be helpful to understand on which team they play.

- Instrument selection. The first thing in any program is to identify the instrument(s) that will be approved for use. This may be done at a state or local level and will also include certain parameters that the instrument(s) must meet (QA).
- Instrument validation/verification/certification. Once approved for use, the instrument(s) are evaluated/certified to ensure they meet the criteria defined in the selection process (QC).

[17] International Organization for Standardization, ISO 9000:2015, *Quality Management Systems—Fundamentals and Vocabulary*, Edition 4 (2015).

- Instrument Calibration. The instruments must be calibrated prior to use. The calibration process ensures the instrument is capable of accurately measuring the concentration of ethanol in a breath specimen (QC). The parameters that must be met during calibration are pre-defined and the process performed according to a procedure (QA). Once the instruments are calibrated, they are issued a certificate of calibration and are deemed certified for use. This process may be done according to a set period or on an as-needed basis, such as instrument repair or failure of a quality control sample.

- Testing. After calibration, the instrument may be used for subject testing. Depending upon the nature of the program there may be one or two tests performed. If two tests are performed there will be pre-defined criteria defining the agreement that the two tests must meet (QA) and the evaluation of this agreement is performed by the instrument (QC).

- Quality Control Samples. During the subject testing process several quality control processes will be evaluated. This will include the evaluation of interferents and the running of control samples. Control samples will consist of negative and/or positive controls. Positive controls consist of a known amount of ethanol introduced into the instrument and evaluated in the same manner as a subject test. The instrument will perform a quantitation of the quality control sample and an evaluation will be made of the accuracy (QC).

- Instrument Checks. On a pre-determined schedule (*e.g.*, daily, weekly, monthly), the instruments will go through a series of checks to ensure adequate performance. These checks may vary between programs but generally will include some internal operational checks as well as the performance of additional quality control samples (QC).

- Records of these certifications, testing, controls, and checks will be maintained by the program for a defined period (QA). These records may be held in a database or filed in hard copy. Technological advances in instruments allow for many to communicate directly with the program, download results, and perform diagnostics remotely.

These examples demonstrate the relationship of QA to QC and help further define the distinction between the two. The following items are additional elements of a quality assurance program.

Accreditation

Accreditation is a formal recognition by a third party that a breath alcohol program is qualified, competent, and complies with international standards. The most common, recognized international standard is ISO/IEC 17025:2017, *General Requirements for the Competence of Testing and Calibration Laboratories*.[18]

[18] International Organization for Standardization and International Electrotechnical Commission, ISO/IEC 17025:2017, *General Requirements for the Competence of Testing and Calibration Laboratories*, Edition 3 (2017, confirmed in 2023).

The accreditation of a breath alcohol program may be voluntary or mandated by legislation within a particular state. One of the primary elements of accreditation is continual improvement. It provides a framework for the program to define and operate a QMS, evaluate risk within the program, and evaluate the operation through audits and reviews.

There may be discussion or references to other types of accreditations. As mentioned above, ISO/IEC 17025[19] is applicable to testing and calibration laboratories. ISO/IEC 17034[20] provides for the accreditation requirements for the creation of reference materials (used in the calibration and quality control processes in breath alcohol). Other ISO accreditation requirements used by industry include ISO 9000[21] and 9001.[22] These generally speak to the overall quality of a system but do not address the specific needs of a testing or calibration laboratory or breath alcohol program. There may also be supplemental requirements specific to, in this case, a breath alcohol program. These supplemental requirements will be defined by the accrediting body and will outline more detailed specifics important for a forensic setting. They will be used in conjunction with the ISO/IEC 17025[23] document during the assessment process.

Accreditation signals to the community that the program meets or exceeds established expectations of quality and competence. Further benefits include the structure to evaluate issues, ensure ongoing training and competence of analysts, continual improvement and updates to the quality management system, and external evaluation of the program's operation. Key elements of an accreditation program include:

- Impartiality/confidentiality
- Resource requirements
- Personnel requirements (including training and competence)
- Facilities and environmental conditions
- Selection/verification/validation of methods
- Handling of test or calibration items
- Evaluation of measurement uncertainty
- Reporting requirements
- Handling non-conforming work/corrective actions
- Quality Management System reviews and internal audits

Accreditation signals to the community that the program meets or exceeds established expectations of quality and competence.

[19] *Id.*

[20] International Organization for Standardization, ISO 17034:2016, *General Requirements for the Competence of Reference Material Producers*, Edition 1 (2016).

[21] ISO 9000:2015, *supra*, note 17.

[22] International Organization for Standardization, ISO 9001:2015, *Quality Management Systems—Requirements*, Edition 5 (2015).

[23] ISO/IEC 17025:2017, *supra*, note 18.

As stated above, accreditation may be mandated by statute or may be voluntary. The absence of accreditation for a breath alcohol program does not automatically invalidate its quality or the competence of its personnel. In this situation the program would need to be evaluated to ensure that processes and procedures are in place to ensure the quality of the calibration and the accuracy of the testing. Instrument selection and verification processes, maintenance of a quality management system, ensuring the competence of personnel, and actions taken to address issues can all be included in a robust and quality breath alcohol program in the absence of formal accreditation.

Uncertainty of Measurement (UM)

A measurement process is desired to be accurate and precise. Accuracy refers to the closeness of a measured value to its true value. Precision refers to the closeness of repeated measurements (two or more) to each other. You can have accuracy without precision and precision without accuracy.

A good analogy is to imagine a baseball pitcher throwing a baseball. If the pitcher is accurate his aim will put the ball in the strike zone each time. If the pitcher is precise, he will put the ball in the same location which may or may not be in the strike zone. So, the pitcher wishes to be both accurate and precise to consistently pitch the ball in the same way each time and each time throwing a strike.

Every measurement or measurement process has a level of expected variability. Repeated measurements will result in different values each time a measurement is made. Depending upon the sensitivity of the measuring process, this difference may or may not be observed. Uncertainty of measurement (also known as measurement uncertainty) is an estimate of the variability of a measurement process based on an evaluation of the measurand (*i.e.*, item being measured) and the measurement process (*i.e.*, method or procedure). The evaluation includes several factors including:

- The individual(s) making the measurement (people performing the calibration)
- The equipment used in the measurement process (instrument(s), thermometers, pipettes, etc.)
- Reference material and/or reference standards used in the measurement process (calibrators, controls) including their preparation and the equipment used to prepare them
- Results of repeated measurements (quality control samples)

Once these factors are evaluated, the UM can be calculated utilizing accepted practices. The UM will quantify the expected variability within a given measurement process. Importantly, the UM should not be confused with errors or mistakes in the process. It should not cast doubt on the process, but, on the contrary, provide confidence in the measurement result.

A measurement process is desired to be accurate and precise. Accuracy refers to the closeness of a measured value to its true value. Precision refers to the closeness of repeated measurements (two or more) to each other.

Initially, an evaluation of the parameters used in the calculation of UM will identify contributors to UM. At this stage, the program can take steps to minimize any contributors that are larger than expected or desired. This, in turn will improve the variability in the process as well as the reported UM.

Once UM is calculated it will be used in a couple of ways. In the issuance of a calibration certificate for the approved/certified instrument, it provides an evaluation of the capability of the breath instrument to precisely measure a sample and will be reported on the calibration certificate. During the testing process, a calculated UM will provide the expected variance of a measured breath test (subject test) and will be reported with the breath test result. Most breath alcohol programs focus primarily on the UM associated with the calibration of the instruments and not the actual subject test as the subject testing may be out of the scope of the breath program.

It is noteworthy that a breath alcohol test result is expected to differ from one test to the next due to the UM. So, a result of 0.100 g/210L and a result of 0.105 g/210L is consistent and does not indicate the subject was still absorbing alcohol (BrAC rising). This is akin to a result of 0.095 g/210L on a second test not indicating the subject was necessarily eliminating alcohol.

Metrological Traceability

Metrological traceability or measurement traceability is a demonstration through an unbroken chain of comparisons to a primary standard. The chain traces back to the SI (international standard) though a National Standard. The National Standard in the United States is NIST (National Institute of Standards and Technology). At each step in a measurement process, this means the equipment or material used in that step has been calibrated or created in such a manner that it is traceable back to the SI. Significantly, in each of these steps, the associated equipment is calibrated with a reported uncertainty of measurement.

Metrological traceability or measurement traceability is a demonstration through an unbroken chain of comparisons to a primary standard.

When calibrating a breath alcohol instrument, the equipment used in the calibration will, itself, be calibrated in a traceable manner. If a thermometer is used to measure the temperature of a wet bath simulator, for example, the thermometer is calibrated by an accredited vendor and in a manner traceable through NIST to the SI. Accordingly, the reference materials (calibrators) are manufactured in a manner traceable through NIST to the SI by a competent manufacturer (accredited to ISO 17034[24] is a good measure of competence). Any equipment used to deliver the reference material such as pipettes or glassware will be accordingly calibrated in the same manner. By ensuring each step in the calibration of the breath alcohol instrument is traceable to the SI, the results of the calibration will, therefore, be traceable to the SI. This process establishes metrological traceability for the calibration of the instrument. It is important to note, the actual equipment is not traceable, it is the result of the measurement or the value of a standard that is traceable.

[24] ISO 17034, *supra*, note 20.

The traceability of a breath alcohol instrument validates the accuracy of its measurement capability. Establishing that an instrument's calibration is traceable to a higher standard (SI) gives credibility to the calibration process and ensures the calibration is accurate and will meet the specifications required for the subject test.

Traceability and uncertainty of measurement are interrelated, and together they establish the accuracy and precision of a measurement process. So, through the evaluation of UM and the establishment of traceability, the breath alcohol instrument calibration can be declared to be both accurate and precise.

ANSI/ASB Standards

The idea of standards within an industry is not new. Traditionally, however, toxicologists in the field of forensic sciences have been responsible for standardization of testing. Instrument manufacturers provided some guidance on the calibration of their instrumentation, but the testing process was, and is, not consistent throughout the United States. In 2009, a report from the National Research Council titled *Strengthening Forensic Science in the United States: A Path Forward*,[25] detailed the need for standardization across forensic science. In the same year, the Scientific Working Group—Toxicology (SWGTOX) was formed.[26] The goal of SWGTOX was to create and disseminate standards and best practices for forensic toxicology. In 2014 the federal government created the Organizational Scientific Area Committees for Forensic Science (OSAC)[27] to accomplish this same goal for all forensic science and includes a Toxicology Subcommittee. This replaced, and dissolved, SWGTOX and the work product, including published documents and working documents, moved to OSAC.

Within OSAC, standards, best practices, and guidelines are created by bringing together industry experts with relevant expertise in the topic being addressed. However, the publication and dissemination of the completed documents was not a part of the mission of OSAC and there needed to be a mechanism to publish the work. This is typically done through a standards organization such as the American Society for Testing and Materials (ASTM)[28] which is used by some of the forensic

[25] Committee on Identifying the Needs of the Forensic Sciences Community, National Research Council. 2009. *Strengthening Forensic Science in the United States: A Path Forward*. Washington, DC: The National Academies Press.

[26] The Scientific Working Group—Toxicology (SWGTOX) was created by the Forensic Toxicology Council (FTC), a group to represent the interests of the major U.S. professional organizations in forensic toxicology, including the American Board of Forensic Toxicology (ABFT), the Toxicology Section of the American Academy of Forensic Sciences (AAFS), and the Society of Forensic Toxicologists (SOFT).

[27] The Organization of Scientific Area Committees (OSAC) is administered by the U.S. Department of Commerce, National Institute of Standards and Technology (NIST). For additional information, visit www.nist.gov/organization-scientific-area-committees-forensic-science, last accessed June 14, 2024.

[28] For additional information, visit www.astm.org, last accessed June 14, 2024.

disciplines in OSAC. In 2015, the American Academy of Forensic Sciences[29] in association with the American National Standards Institute[30] created the Academy Standards Board[31] to accomplish the goal of publishing the work of OSAC. This is the route the Toxicology Subcommittee chose as the mechanism to disseminate its work. The published standards are free to access, use, and implement by forensic practitioners.[32]

Currently, the implementation of these standards, best practices, and guidance documents is voluntary. They may be implemented fully, partially, or not at all by programs throughout the United States. Implementation of these standards in a breath alcohol program leads to consistency, quality, efficiency, and ultimately better customer satisfaction. They provide a framework in which programs may operate consistent with the expectations of the field and bring uniformity to the calibration and testing process while harmonizing data.

As with accreditation, the lack of implementation of standards does not automatically invalidate the quality of a breath alcohol program. There may be many reasons why a program may not fully adopt a standard including legislation, legal frameworks, or budget. In this situation, the program would need to be evaluated to ensure that processes and procedures are in place to safeguard the quality of the calibration and the accuracy of the testing.[33] Instrument selection and verification processes, maintenance of a quality management system, ensuring the competence of personnel, and actions taken to address issues can all be included in a robust and quality breath alcohol program in the absence of standards implementation.

The discussion above outlines some of the practices aiding the development and implementation of a quality breath alcohol program. A full quality management system considers every step from ordering supplies to the final test result, the competence of analyst and training of breath test operators, the selection of adequate instrumentation, and calibration practices consistent with manufacturer and industry expectations. This also includes documentation of issues discovered throughout the calibration or testing process. Issues, when acknowledged and corrected, demonstrate the operation of a robust quality management system, and should not be interpreted as a failure of a program. Additionally, these issues should not be interpreted as affecting a specific breath alcohol result if they are not directly related to the subject test, timeframe of testing, or individuals involved in the calibration or testing.

Instrument selection and verification processes, maintenance of a quality management system, ensuring the competence of personnel, and actions taken to address issues can all be included in a robust and quality breath alcohol program in the absence of standards implementation.

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[29] For additional information, visit www.aafs.org, last accessed June 14, 2024.

[30] For additional information, visit www.ansi.org, last accessed June 14, 2024.

[31] For additional information, visit www.aafs.org/academy-standards-board, last accessed June 14, 2024.

[32] *Id.*

[33] The evaluation of a program in the absence of the adoption of standards could come through accreditation (which is separate from the adoption of standards) or the program itself through internal audits, quality systems, etc. It could also be evaluated externally through those who would question the validity of a program.

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.

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.

> **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.

Discovery and Foundational Challenges to Results

Discovery and notice requirements will vary substantially between jurisdictions. A prosecutor should know their state's laws, discovery rules, notice and expert witness requirements.

Generally, the different brands of breath testing instruments generate similar documentation. This documentation may be part of mandatory discovery, depending on the jurisdiction. These documents frequently include the following:

- Initial and/or Annual Operator Certification or Training—Training, certification, or other proof the administering officer is qualified to administer testing.
- Monthly or Quarterly Instrument Certification—These regular certifications verify the instrument is producing results within the expected range using the verified standard.

- Standard Verification
    - Breath instruments may use a verified standard to test the instrument and ensure it is producing results within an expected range. These gas standards are often bottle or cannisters screwed into the instrument. The gas standards are shipped with a certificate of analysis detailing the results of verification testing.
    - Wet standards, used in conjunction with a simulator, are another way to verify an instrument is functioning properly.
    - Finally, some instruments can produce an internal standard (simulated alcohol standard) for verification.
- Annual Instrument Calibration, Verification, or Certification—Annual certifications are extensive calibration and verification checks by qualified experts. Oftentimes, it requires shipping the instrument offsite for a week or more.

Developing a systematic approach to collect, disseminate, and receive the breath instrument documentation can avoid needless pretrial discovery litigation. Officers should include this documentation as part of their case file, and prosecutors should review and ensure the documentation is included. Providing the documentation to the prosecutor allows for early notice of potential prosecution experts, such as the technician who performed the annual instrument calibration, well in advance of any deadlines. Similarly, including the documentation early during the discovery process helps avoid unnecessary legal issues that could compromise the case. A predetermined systematic and consistent approach to sharing this documentation alleviates confusion and streamlines the prosecution.

Developing a systematic approach to collect, disseminate, and receive the breath instrument documentation can avoid needless pretrial discovery litigation.

Right to Confrontation Challenges

The Sixth Amendment provides, in part, "In all criminal prosecutions, the accused shall enjoy the right … to be confronted with the witnesses against him…." The United States Supreme Court has shaped this right to confrontation to require the testimonial statement of a witness absent from trial is admissible only when the declarant is unavailable, and only when the defendant has had a prior opportunity to cross-examine the declarant.[34] The "primary purpose" test is used to ascertain whether a statement is testimonial or nontestimonial.[35] The inquiry must consider "all of the relevant circumstances" and has evolved over time.[36]

[34] *Crawford v. Washington*, 541 U.S. 36, 59, 124 S. Ct. 1354, 1369 (2004).

[35] *Davis v. Washington*, 547 U.S. 813, 822, 126 S. Ct. 2266, 2273 (2006).

[36] *See, e.g., Michigan v. Bryant*, 562 U.S. 344, 369, 131 S. Ct. 1143, 1162 (2011); *Ohio v. Clark*, 576 U.S. 237, 135 S. Ct. 2173 (2015).

The United States Supreme Court recently ruled on a case involving the issue of confrontation and the limitation of forensic scientists testifying based upon the work of others.[37] In *Smith v. Arizona*, the Court held when an expert conveys an absent lab analyst's statements in support of the expert's opinion, and the statements provide that support only if true, then the statements come into evidence for their truth, and thus implicate the Sixth Amendment's Confrontation Clause. It is yet unknown whether or how this will affect breath instrument certifications and admitting breath tests into evidence.

With respect to a breath test instrument's certification documentation, the "primary purpose" of it is to ensure the instrument is generally functioning correctly and the operator is trained to administer breath testing. The primary purpose of the certification documents is not to produce evidence against a particular defendant. Rather, the defendant's individual breath test result from the investigation is the testimonial evidence produced for the purpose of prosecution. Many jurisdictions have deemed certification documents nontestimonial for precisely this reason.[38] Some jurisdictions have even held that the breath test report produced by the instrument is nontestimonial, given that it is self-explanatory data produced entirely by a machine.[39] Given the shifting legal landscape, prosecutors should carefully review the Court's ruling in *Smith v. Arizona* and determine whether the certification documents and instrument-generated breath test results qualify as testimonial or non-testimonial.

Source Code Discovery Challenges

Source code is the human readable format of the software controlling the operation of breath testing instruments.[40] In other words, the source code provides instruction to the instrument on how to calculate the numerical result, such as 0.08 g/210L, based on the collected data.[41] If the source code contains an error, it could potentially affect the accuracy of the breath test results. Even a minor mistake in the code might lead to incorrect calculations, which could have serious legal implications in an impaired driving case. To mitigate this risk of errors, however, breath testing instruments incorporate checks and balances within the source code. For example, the instrument may cross-reference its output with external measures or predefined thresholds. Additionally, the source code must incorporate mathematical functions that allow the instrument

[37] *See Smith v. Arizona*, __ U.S. __ (2024).

[38] *See, e.g., State v. Beeler*, 281 A.3d 637, 2022 ME 47(2022); *State v. Bergin*, 231 Or.App. 36, 217 P.3d 1087 (2009); *People v. Ambrose*, 506 P.3d 57, 2021 COA 62 (2021); *State v. Kramer*, 153 Idaho 29, 278 P.3d 431 (2012).

[39] *See, e.g., State v. Tozier*, 115 A.3d 1240, 2015 ME 57 (2015); *People v. DiNardo*, 290 Mich. App. 280, 801 N.W.2d 73 (2010); *State v. Buckland*, 313 Conn. 205, 96 A.3d 1163 (2014); *State v. West*, 250 Or.App. 196, 279 P.3d 354 (2012).

[40] *See, e.g., State v. Peters*, 2011 MT 274, ¶ 4, 264 P.3d 1124.

[41] *Id*.

to apply Henry's Law and the 2100/1 ratio. These principles are essential for accurate alcohol concentration measurements. Breath test instrument makers are extremely protective of their source code, because it is a trade secret and release could result in their code ending up in the hands of business competitors.

A defendant may hire an expert who wishes to obtain a copy of the source code.[42] Whether source code is discoverable will vary by jurisdiction. The source code is not typically in the possession of the state. Rather, as discussed above, it is protected and kept by the manufacturer. If a jurisdiction considers source code discoverable, and defense requests it, the prosecutor should work with their breath test program manager to contact the breath instrument manufacturer and clarify under what conditions a defense expert may be permitted access to the source code. Access conditions may include non-disclosure agreements, in-person access at the manufacturer's secure facilities, and strict limitations on copying, transmitting, or removing source code.[43] A prosecutor should remain aware of the occasional request for access not made in good faith as well as the lack of follow through by some defense once the source code is made available, as described above.

The Officer Did Not Comply with All the Rules Challenges

Most states have established judicially recognized rules and procedures to ensure the accuracy and reliability of breath testing. Consequently, defendants often challenge breath test results by alleging violations of these rules by the officer or operator, arguing such violations undermine the accuracy and reliability of their test results. They typically insist the breath test results should be suppressed if the officer or operator ignored, skipped, or otherwise violated an administrative rule.

In almost all states, breath tests are admissible if administered in substantial compliance with the rules. Judges should therefore admit breath test results unless the alleged deviation(s) raise substantial and legitimate questions about the accuracy and reliability of the tests, which would prejudice the defense. A prosecutor must evaluate a defense claim on a case-by-case basis. A prosecutor should be well-versed in their jurisdiction's administrative codes, agency policies, and training procedures. Additionally, they should understand the rationale behind each rule and determine whether the alleged deficiencies truly render the test results unreliable. Claims involving minor deviations or speculative issues affect the weight of the evidence, rather than its admissibility.

In almost all states, breath tests are admissible if administered in substantial compliance with the rules.

42 *In re Source Code Evidentiary Hearings in Implied Consent Matters*, 816 N.W.2d 525 (Minn. 2012).

43 *See, e.g., Peters*, at ¶¶ 8–12.

Residual Mouth Alcohol Affected the Results Challenges (Including residual mouth alcohol from burping, belching, piercings, dentures, retainers, braces, grills, blood, and face masks)[44]

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
- A substance regurgitated or eructated (burped) from the stomach or gastroesophageal 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 studied subjects with dentures and mouth jewelry. Those studies found if a person refrains from eating anything or regurgitating any fluids for 15 minutes, there will be no residual alcohol in their mouth. Regardless, it is unlikely 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 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 the subject did not ingest or regurgitate any substances. To avoid confusion, operators should record the time they begin their observation.

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 jurisdictions).

In the recent past and a result of widespread public health guidelines during the Covid pandemic, face masks were worn by many people and presented a new question for law enforcement officers when confronted with the prospect of a breath test. A breath test operator should ensure any mask is removed during the observation period and the breath test. This allows for proper observation and prevents any interference with the test.

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

[44] Logan BK, Gullberg RG. "Lack of effect of tongue piercing on an evidential breath alcohol test." *J Forensic Sci.* 1998 Jan;43(1):239–40. J. G. Modell, J. P. Taylor, J.Y. Lee, "Breath Alcohol Values Following Mouthwash Use," *JAMA*, 2955 (Dec. 1993).

content 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. Other potential safeguards or factors include the following:

- 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

Radio Frequency Interference (RFI) Inflated the Results Challenges

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.[45] The researchers measured the Intoxilyzer™ under various RFI conditions with different field strengths and distances and determined the instrument functioned properly.

Environmental Influences Contaminated the Results Challenges

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 g/210L demonstrates the air is "clean" and 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.

With the recent pandemic, the use of chemical sanitizers for cleaning hands and surfaces became much more prevalent. Some of these sanitizers (especially hand sanitizers) contain very high levels of ethyl alcohol. If these products are used near the EBT, they may cause issues with the "air blank," standard test or other parts of the subject test. The instrument will stop the test and inform the operator if this happens.

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[45] For additional information about this study, readers are invited to contact the manufacturer directly.

Operator Erred or Manipulated the Results Challenges

Modern EBTs perform automatic diagnostic checks during each breath test. Although the operator initiates the test, the software within the instrument manages the entire process. If the operator does not give proper instructions to the subject or fails to allow adequate time for the subject to complete the test, it may result in an artificially low reading. However, the operator cannot influence the test to produce a reading higher than the subject's actual Breath Alcohol Concentration (BrAC). In addition, if the operator does something outside the instrument's programmed protocols (*i.e.*, requesting a subject to provide a sample at the improper time), most instruments will stop the testing process and inform the operator of the mistake.

The Wet Bath Simulator Used to Test the Instrument Was Not Working Properly Challenges

Simulator solutions in many jurisdictions are stored in polyethylene (plastic) containers when they are not in use. A defense expert may argue volatile solutions such as alcohol should be stored only in glass containers at 4° Celsius. While storage in glass containers may be appropriate for trace analysis, it is unnecessary for alcohol simulator solutions. Regardless, laboratories and law enforcement agencies can eliminate the issue altogether by creating and following clearly written policies regarding the preparation, storage, distribution, and use of simulator solutions.

A defense attorney may sometimes question the accuracy of the thermometers that measure the temperature of the simulator solution during use with an EBT. The temperature of simulator solution is critical to ensure the appropriate application of Henry's Law (*see* above). Like all other analytical instruments, every thermometer makes a measurement and has an inherent uncertainty. This uncertainty of measurement (*see* discussion above) is expected and does not 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 exist. 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 multiple instruments would have equal but opposite deficiencies to a simulator. A robust Quality Management System will have policies and protocols for calibration maintenance of equipment including simulators. It will also have processes for ensuring the accuracy and precision of the testing process including utilization of the simulator. These checks and balances ensure the proper functioning of the simulator and identify issues should they occur.

If the operator does not give proper instructions to the subject or fails to allow adequate time for the subject to complete the test, it may result in an artificially low reading.

Breath Test Results vs. SFST Performance/Appearance on Camera Challenges

When responding to a defense claim that the breath test results do not match the defendant's performance on Standardized Field Sobriety Tests (SFSTs) or their appearance on camera, a prosecutor should focus on the following points:

- Emphasize the Objectivity of Breath Tests—A prosecutor should highlight the breath test provides a scientific and objective measurement of the defendant's breath alcohol concentration (BrAC), which is more precise and reliable than the subjective interpretation of SFSTs or video evidence.
- Acknowledge Individual Variations—A prosecutor should explain individuals may perform well on SFSTs despite high BrAC concentrations, while others may appear more impaired at lower BrAC levels. Similarly, appearances on camera can be misleading due to various factors.[46]
- Discuss Limitations of SFSTs and Video Evidence—A prosecutor should note SFSTs and video footage can be influenced by many variables, such as the subject's physical condition, nervousness, environmental conditions, and camera angles, which can impact their evidential value.
- Consider Timing and Metabolism—A prosecutor should point out BrAC can change over time due to alcohol metabolism, and there may be a time gap between the SFSTs and the breath test. The breath test reflects the BrAC at the moment of testing, which may not exactly match earlier or later observations.
- Advocate for Comprehensive Evidence Review—A prosecutor should urge the court to consider all evidence in its entirety. The breath test results, SFST performance, and video evidence together provide a comprehensive view of the defendant's impairment. It should be emphasized that the breath test is a scientifically validated measurement and should not be dismissed based on perceived inconsistencies with other evidence.

By presenting these points, a prosecutor can effectively argue the breath test results are reliable and should be considered alongside other evidence to provide a full picture of the defendant's level of impairment.

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[46] In person SFST performance provides perspective that may not easily be captured via camera due to factors such as the area lighting conditions, the camera perspective or camera angle relative to the observed behavior (*e.g.*, eye movements during the Horizontal Gaze Nystagmus test), and the differences between perspectives provided by two-dimensional versus three-dimensional observations. Additionally, non-visual clues, such as odors/smells, some audio, and some other behaviors may be impossible or difficult to discern through a camera.

Operating Below the "Legal Limit" Challenges

It is illegal to drive under the influence of alcohol in all 50 states and the District of Columbia. All states also have "per se" laws making it illegal to drive with a certain concentration of alcohol in a person's breath.[47]

For a case involving a theory of impairment, the jury is tasked with determining whether the suspect's ability to safely operate a vehicle was diminished as a result of taking into the body alcohol and/or drugs. For a case involving a per se violation, on the other hand, the jury must determine whether the suspect had within their body a threshold breath/blood alcohol or drug concentration.[48]

In most jurisdictions, however, it is possible for a driver to be guilty of an impaired driving offense, even if the breath test result is below the per se threshold. For example, a person with a BrAC of 0.072 g/210L may still be convicted in many states if it can be demonstrated their ability to safely operate a vehicle was impaired by the alcohol they consumed.

In an impaired driving case, a defendant may claim to be not guilty if the breath test results are below the state's per se threshold. A defendant may refer to the per se threshold as the "legal limit." This implies a person below the per se threshold was ostensibly operating legally, akin to driving below a posted speed limit. Unlike a speed limit, however, a person can still be guilty of impaired driving, even if their breath results are below the per se threshold. Using the term "legal limit" in this instance is irrelevant, misleading, misstates the law, confuses the two different ways to prove a DUI case, and impermissibly begs the jury to acquit a defendant. A prosecutor litigating an impairment DUI case with a breath result below the state's per se limits (but above any negative presumption limits[49]), should consider filing a pretrial *motion in limine* prohibiting referencing, arguing, or using the misleading term "legal limit."[50]

It is illegal to drive under the influence of alcohol in all 50 states and the District of Columbia. All states also have "per se" laws making it illegal to drive with a certain concentration of alcohol in a person's breath.

[47] In most states, per se concentration of alcohol in a person's breath is 0.08 g/210L, at which or above is illegal. Utah's illegal amount is 0.05 g/210L. Other concentrations are also illegal; some states have zero tolerance for drivers under the age of 21, for example, or set the illegal concentration at 0.02 g/210L. The illegal concentration for a commercial driver is 0.04 g/210L.

[48] Although the focus of this monograph is impairment by alcohol, the reference to "drug" is included here given the ongoing research to detect the presence of THC, the psychoactive component of Cannabis, in breath for the indication of Cannabis use.

[49] *See, e.g.,* Mont. Code Ann. § 61-8-1002(2)(a).

[50] Irrelevant evidence is inadmissible. Fed. R. Evid. 402. Courts may exclude relevant evidence if its probative value is substantially outweighed by a danger of confusing the issues or misleading the jury. Fed. R. Evid. 403. During opening and closing, calling the presumptive 0.08 the "legal limit" is a misstatement of the law, and can be prohibited.

The Defendant's Partition Ratio is Not 2100:1 Challenges

(*See Partition Ratio*, above, for additional details.)

A defendant may sometimes challenge the accuracy of a breath testing instrument by arguing the standard partition ratio used to convert the breath alcohol concentration to blood alcohol concentration is not accurate for some individuals. In most jurisdictions, this argument is legally irrelevant and a *motion in limine* may disallow such arguments.

Put simply, a partition ratio is the ratio at which a volatile compound will equalize between a liquid and air in a closed container. As it relates to an alcohol breath sample, it is the ratio of alcohol in the subject's deep lung air and their blood, respectively. Most jurisdictions which allow breath testing define "alcohol concentration" as *either* grams of alcohol per 100 milliliters of blood or grams of alcohol per 210 liters of breath. Such a definition eliminates the need to convert a breath alcohol concentration to a blood alcohol concentration.[51] Rather, the definition dictates, by law, what partition ratio the jurisdiction's breath testing instrument must use. Grams of alcohol per 210 liters of breath thus requires a partition ratio of 2100:1.[52]

A prosecutor who anticipates a defendant attempting to introduce arguments regarding partition ratios should consider filing a pretrial *motion in limine* prohibiting referencing, arguing, or urging the jury to consider an illegal partition ratio.[53]

If a law enforcement officer is confronted with a suspect who is not providing an adequate breath sample, it is highly likely the suspect is deliberately undermining the test.

Inadequate Breath Sample/Refusal Challenges

Most breath testing instruments require a minimum breath sample of 1.1 or 1.5 liters of breath. The overwhelming majority of the population should be able to provide this sample amount. If a law enforcement officer is confronted with a suspect who is not providing an adequate breath sample, it is highly likely the suspect is deliberately undermining the test. Law enforcement should be

[51] Historically, many jurisdictions only defined alcohol concentration in terms of blood alcohol concentration, requiring conversion from breath to blood and opening the door to challenge partition ratios.

[52] Studies suggest breath testing ratios would generally be more accurate using a much higher ratio than 2100:1. *See, e.g.*, Jones AW, Andersson L. "Variability of the blood/breath alcohol ratio in drinking drivers." *J Forensic Sci.* 1996 Nov;41(6):916–21. This means breath tests using a 2100:1 ratio generally produce lower "alcohol concentrations" than blood test results. This substantially benefits a defendant.

[53] Irrelevant evidence is inadmissible. Fed. R. Evid. 402. Courts may exclude relevant evidence if its probative value is substantially outweighed by a danger of confusing the issues or misleading the jury. Fed. R. Evid. 403. *See, e.g., People v. Vangelder*, 164 Cal. Rptr. 3d 522, 312 P.3d 1045 (2013); *Guthrie v. Jones*, 202 Ariz. 273, ¶¶ 10–11, 43 P.3d 601 (Ct. App. 2002); *People v. Bransford*, 35 Cal. Rptr. 2d 613, 884 P.2d 70 (1994); *State v. Hardesty*, 136 Idaho 707, 39 P.3d 647 (Ida. App. 2022); *State v. McManus*, 152 Wis.2d 113, 447 N.W.2d 654 (1989).

encouraged to provide multiple opportunities and caution the suspect that feigning an inability to provide an adequate breath sample may be considered a refusal with the associated consequences, like suspension of a driver's license or the admissibility of a negative inference in trial. Law enforcement should also consider pursuing a search warrant to obtain a sample of blood from the uncooperative suspect.

In a feigned inadequate sample case, a prosecutor should consider making use of demonstrative exhibits at trial to illustrate for the jury how easy it is to provide a proper sample. For example, calling an instrument technician to testify and asking them to bring along an instrument for a demonstration can be very effective.

Gastroesophageal Reflux Disease (GERD) Falsely Elevated the Breath Test Results Challenges

When a GERD episode occurs, the stomach contents flow back into the esophagus causing a backwash of acid into the mouth. While the defendant may point to a study which suggests the breath alcohol content did in fact rise from GERD,[54] there are limitations to the study including the fact there were only fifteen test subjects in the study. Additionally, while three of the fifteen subjects did exhibit higher BrACs, the study found "breath samples contaminated by GERD-related alcohol leakage from the stomach into a breath sample were found only when there was a high concentration of alcohol in the stomach. When contaminated breath samples were encountered, they were irreproducible in magnitude."[55]

In another study, the scientists concluded "the risk of alcohol erupting from the stomach into the mouth owing to gastric reflux and falsely increasing the result of an evidential breath-alcohol test is highly improbable."[56]

The officer should be vigilant in observing the subject during the deprivation period and document the subject did not burp, vomit, or regurgitate anything. As a best practice tip, if the subject continues to do any or all of these things, the officer should transport them to the hospital and secure a search warrant for a blood draw. If burping occurred during the deprivation period, and burping is not specifically addressed in the state's administrative rules (*i.e.*, only vomiting is addressed), a prosecutor should be prepared for the defendant's argument at trial or suppression hearing that it was a "wet" burp, some of their stomach's content came back up into their throat, and they swallowed it back down before the officer noticed.

The officer should be vigilant in observing the subject during the deprivation period and document the subject did not burp, vomit, or regurgitate anything.

[54] *See* Booker JL, Renfroe K. The Effects of Gastroesophageal Reflux Disease on Forensic Breath Alcohol Testing. *J Forensic Sci.* 2015 Nov;60(6):1516–22.

[55] *Id*.

[56] *See* Kechagias S, Jönsson KA, Franzén T, Andersson L, Jones AW. "Reliability of breath-alcohol analysis in individuals with gastroesophageal reflux disease." *J Forensic Sci.* 1999 Jul;44(4):814–8. *See also* Gullberg RG. Breath alcohol analysis in one subject with gastroesophageal reflux disease. *J Forensic Sci.* 2001 Nov;46(6):1498–503. PMID: 11714167.

Diabetes, Ketones, or Fasting Falsely Elevated the Breath Test Results Challenges

Ketones are a chemical often produced when an individual has a low calorie or low carbohydrate diet. Uncontrolled diabetics and individuals who fast for weight loss can be especially prone to being in a state of ketosis. A breath test instrument's technology should not produce a falsely high result when a subject is experiencing ketosis. The best safeguard to protect against this claim, however, is by conducting a thorough roadside interview. The officer may inquire as follows:

- Do you have any medical conditions? If so, what are they?
- Do you see a medical doctor regularly?
- What types of medications are you on?
- When is the last time you took your medication?
- How much did you take?
- What type of diabetes do you have? (The answer should be either Type 1 or Type 2.)
- How long have you been diabetic?
- Do you consider yourself to be in good control of your diabetes?
- What is your average blood sugar?
- When is the last time you tested your blood sugar?
- Do you know what your blood sugar is currently? (Many diabetics now use a continuous blood glucose monitor with an app on their phone that will immediately tell what their blood sugar is.)
- When is the last time you ate?
- What did you eat?

By asking these questions, and properly documenting a subject's responses, the officer minimizes the ability of the defendant to formulate different answers at a later date or to introduce something contrary in court. Additionally, it is essential to ask these questions roadside prior to the subject realizing what their BrAC concentration is.

If while on scene, the subject reports being a diabetic and is displaying severe signs of impairment such as being incoherent or fading in and out of consciousness, the officer should immediately call for an ambulance or transport the subject to the hospital for further evaluation. A condition of low blood sugar or hypoglycemia can often be confused with alcohol/drug impairment. If the subject's blood sugar becomes dangerously low, this can result in a comatose state or death. Once at the hospital, medical personnel will likely blood draw to determine their blood glucose level. The prosecutor can then subpoena

The best safeguard to protect against a claim of diabetes/ketones falsely elevating the breath test results is by conducting a thorough roadside interview.

the defendant's medical records to confirm whether their condition was from diabetes, alcohol/drug consumption, or both.

Interfering Substances Affected the Results Challenges

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[57] 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.

Only one potentially interfering substance, in fact, has been shown to exist in measurable concentrations in the human body over time: acetone. The body produces acetone, a ketone, as a byproduct of incomplete digestion in a very few individuals, such as diabetics whose insulin levels are not controlled (as described above). 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 the:

- 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 they measure alcohol only. Over time, manufacturers added additional wave-lengths 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.

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57 For example, an extreme or desperate drinker may drink isopropyl alcohol instead of ethanol. Other volatile substances could be present if a person was huffing, but these individuals would have other indicators and breath tests likely would not be performed. *See* case example in the box below.

Case Example[58]

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 contents on evidential breath tests carried out less than 30 minutes after exposure to the solvents has ceased."

Tobacco in the Mouth Falsely Elevated the Breath Test Results Challenges

The most effective way to guard against this claim is for the officer to be certain to check the oral cavity prior to the start of the deprivation period. Most states' Administrative Rules will address this and will prohibit the subject from putting any foreign substance in their mouth prior to testing. Even if the Administrative Rules do not direct the officer to check the defendant's oral cavity at the beginning of the deprivation period, it is strongly advisable so it may be ruled out as an issue later.

[58] Denney RC. Solvent inhalation and 'apparent' alcohol studies on the Lion Intoximeter 3000. *J Forensic Sci Soc.* 1990 Nov–Dec;30(6):357–61. doi: 10.1016/s0015-7368(90)73375-0. PMID: 2093101.

Auto-Brewery Syndrome, Not Alcohol, Elevated the Breath Test Results Challenges

Auto-brewery is a rare condition generally caused by fermentation in the gut, typically in those individuals with a high carbohydrate, high sugar diet. It can also be caused by overuse of antibiotics and chronic yeast infections. Because this syndrome can result in alcohol production in the body, it can cause an individual to exhibit signs of intoxication and a possible breath test result in excess of the illegal limit. Individuals who suffer from auto-brewery syndrome are significantly affected by it and often have other co-morbidities such as obesity, diabetes, and Crohn's disease.[59]

This condition is often associated with other symptoms such as vomiting, dizziness and loss of coordination, making it less likely for an individual with auto-brewery syndrome to be operating a vehicle. Ruling out a condition like this can often be done through a thorough roadside interview about the subject's diet and medical conditions. Additionally, if the subject is presenting with symptoms of disorientation, vomiting, and dizziness, calling an ambulance to the scene or transporting the subject to the hospital would be the appropriate action. Once the subject is evaluated by medical professionals, the prosecutor can subpoena the hospital records to eliminate auto-brewery syndrome as the cause of the subject's condition.

Auto-brewery syndrome is often associated with other symptooms such as vomiting, dizziness and loss of coordination, making it less likely for an individual with it to be operating a vehicle.

[59] For additional information on Auto-Brewery Syndrome, *see* any of the following:

- J. Booker, K. Renfroe, "The Effects of Gastroesophageal Reflux Disease Effects on Forensic Breath Alcohol Testing." *J Forensic Sci.* 2015 Nov;60(6):1516–22.
- Kechagias, S., Jönsson, K. Å., Franzén, T., Andersson, L., & Jones, A. W. (1999) "Reliability of breath-alcohol analysis in individuals with gastroesophageal reflux disease," *J Forensic Sci.* 44(4),814–818.
- Painter, K., Cordell, B., & Sticco, K., 2023, *Auto-Brewery Syndrome*, NIH, National Library of Medicine, May 1, 2024.
- National Traffic Law Center. *Challenges and Defenses III, Responses to Common Challenges and Defenses in Impaired Driving Cases*. National District Attorneys Association, August 2022, pp. 27–30.

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 and Resources

Manufacturer Contact Information

- CMI, Inc. manufactures the Intoxilyzer brand of breath testing products
  www.alcoholtest.com
- Intoximeters, Inc. manufactures desktop breath testing instruments, including Intox EC/IR II, Intox EC/IR II.t, Intox DMT, Intox DMT Dual Sensor, and Alcomonitor CC®--Refurbished, as well as portable breath testers including RBT VXL, Alco-Sensor VXL, RBT IV, and Alco-Sensor®VXL.
  www.intox.com
- Lifeloc Technologies manufactures L Series and FC Series breath alcohol testers or breathalyzers.
  lifeloc.com/fc10
- Dräger manufactures the Dräger Alcotest© 9510 evidential breath tester.
  www.draeger.com/en-us_us/Home
- ILMO Specialty Gases manufactures dry gas standards for BrAC testing equipment.
  ilmoproducts.com/industries-served/specialty-gas/brac-dry-gas-standards/

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.

Artifact. 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.