The Intoxilyzer 9000 & the Unknown

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Introduction

When a jurisdiction adopts a new technology, they gain an immediate advantage in the courts. First, the new technology should, ideally, replace any fundamental flaws in existing technology. Secondly, they have an opportunity to address operational issues during training on the new technology. Standard operating procedures can be changed, and officers trained on the new standard in order to incorporate the technology seamlessly. Finally, prosecutors can present evidence to the courts with an understanding that it represents the latest technology, incorporating advances that should make the evidence more reliable.

Unfortunately, the implementation of new technology has another aspect. Defense lawyers may not be up to speed on the new technology. Prosecutors may have been given training or in-service updates or bulletins on the new technology, but this information is often not extended to the defense bar. Existing and established experts may not be allowed to testify about the new technology as they are often excluded, too, from training on the devices. Finally, new tech brings about a minor black hole of information. Training manuals and independent reviews of the technology are often absent for a year or more.

During this time, a defendant may not receive an adequate defense in their case. The lawyer, untrained at the operation and not knowing any inherent deficiencies in the device cannot ask the appropriate questions and make the appropriate challenges to the evidence offered. Defense counsel will often be required to operate without benefit of a retained expert – the expert being uncertain as well about the new device, and unable to testify in any event, due to lack of training or familiarity with the device. Finally, implementation of many system changes may bring about substandard operation of the devices, as officers need to familiarize themselves with the performance characteristics of the new technology.

The Intoxilyzer 9000

A little history…

Intoxilyzer began producing a modern version of an infrared breath alcohol detection device in the late 1970s. The earliest instrument, the Intoxilyzer 4011, used a single infrared reading to determine the presence and concentration of ethanol in the breath sample. By the mid 1980s, they adopted a multi-wavelength device in the Intoxilyzer Model 5000 series. By the end of that models run, the device was measuring up to five separate readings in the 3.4 – 3.8 micron range to provide a Breath Alcohol Concentration reading (BrAC).

Figure 1 - The Intoxilyzer Model 5000EN

Figure 2 - The Intoxilyzer Model 8000

In early 2000, Intoxilyzer released the Model 8000. It was considered at the time a more reliable, more portable version of the 5000, reducing one of the 5000's inherent weak spots – the rotating filter or "chopper" wheel. The 8000 used, for the first time, readings in the 9-micron range (and also the 3-micron range) to determine a BrAC reading. However, various challenges to the 8000 demonstrated that it had some reliability issues. Enter the Model 9000…

The Intoxilyzer Model 9000 started coming into service around 2012. The state of Georgia was one of the first adopters of the 9000, followed by Colorado, and most recently, Texas. An evaluation report was prepared in Georgia by the Georgia Bureau of Investigation (GBI) indicating its suitability, and work was also done in Colorado to determine the reliability of the 9000. While the Georgia report was made public, the Colorado Department of Public Health and Environment (CDPHE) did not publish the results of their findings. Additionally, the reviewer for the CDPHE apparently destroyed his own notes, readings, and analysis of the data.

Figure 3 - The Intoxilyzer Model 9000

What we know, and don't know, about the Intoxilyzer 9000

Most of what we know about the Intoxilyzer 9000 comes from the GBI 2012 report, from the specifications published about the 9000 by its manufacturer, CMI Inc., Plus some FOIA requests from Texas and Colorado. It is important to understand that in most cases, specific operational characteristics and components of the 9000 are compared to the older 5000 models.

> ***We need to understand the accuracy, precision, specificity and reliability of a device, and to be able to assess how it deals with substandard acts, substandard conditions, and substandard practices.***

Components of the Intoxilyzer 9000

It is perhaps easiest to break the Intoxilyzer 9000 into sub-assemblies and components, and to differentiate hardware from software-driven features. It is also easiest to compare the Intoxilyzer 9000 to other known units, most notably the Intoxilyzer 5000EN – widely used and understood in many jurisdictions before the implementation of the Intoxilyzer 9000.

Some Intoxilyzer Model 5000 units are available to independent third-party forensic criminalists, toxicologists, or scientists for evaluation and testing. As of this writing, I am not aware of any Intoxilyzer 9000 units being in private hands. This is important.

Without independent third-party testing, the veracity and reliability of ANY evidentiary testing device is unknown. Given that testing data has been destroyed in Colorado by the CDPHE, and was not published in the GBI reports, any information we have is, by definition, both here say and uncorroborated.

Breath Sampling System

The breath sampling system consists of a series of tubes, both external and internal, that draw in room air, breath samples, and calibration solution into the optical chamber (or bench). Additionally, this sub-assembly requires opening and closing of valves in sequence, and a means to measure the flow rate of the exhaled breath sample.

We do not know the flow characteristics of the Intoxilyzer 9000 in terms of its required flow rate, exhalation volume, and minimum sampling requirements. The GBI report does not contain specific data regarding these requirements, and they are not listed by CMI.

Specifications regarding flow rate, exhalation volume and minimum sampling requirements are critical in determining the *suitability* of a sample. Although one can infer some of these minimal requirements from the 9000's histogram, the minimum threshold requirements are unknown, and have not been independently verified in any event. Therefore, person's suffering from respiratory ailments such as Asthma and COPD[1], or those with minimal lung volumes or overall physical size, may be regarded as "refusing" to provide a sample when in fact they are physically incapable of meeting the minimum sample requirements.

Optical Chamber (or Optical Bench)

The Optical chamber, often referred to an as Optical Bench, consists of a chamber, tube or pathway in which both a room air, wet-bath solution or dry-gas calibration standard, or exhaled breath sample are analyzed. Light or heat energy will also pass through the air, gas, or breath sample to determine the presence and concentration of ethanol in the sample.

We do not know the size of the optical chamber. This is critical, in that larger optical chambers require a larger exhalation volume. A larger sample is thought to deliver a more *analytically precise* measurement. Folded-path chambers are often utilized to deliver a more precise measurement as well. We know the 9000 does not utilize a folded pathway. We don't know its volume, and physical specifications. Older units employed aluminum chambers that were sensitive to pitting and corrosion, or that promoted the growth of mold. Some devices use polished stainless steel chambers. What are the 9000's characteristics in this regard?

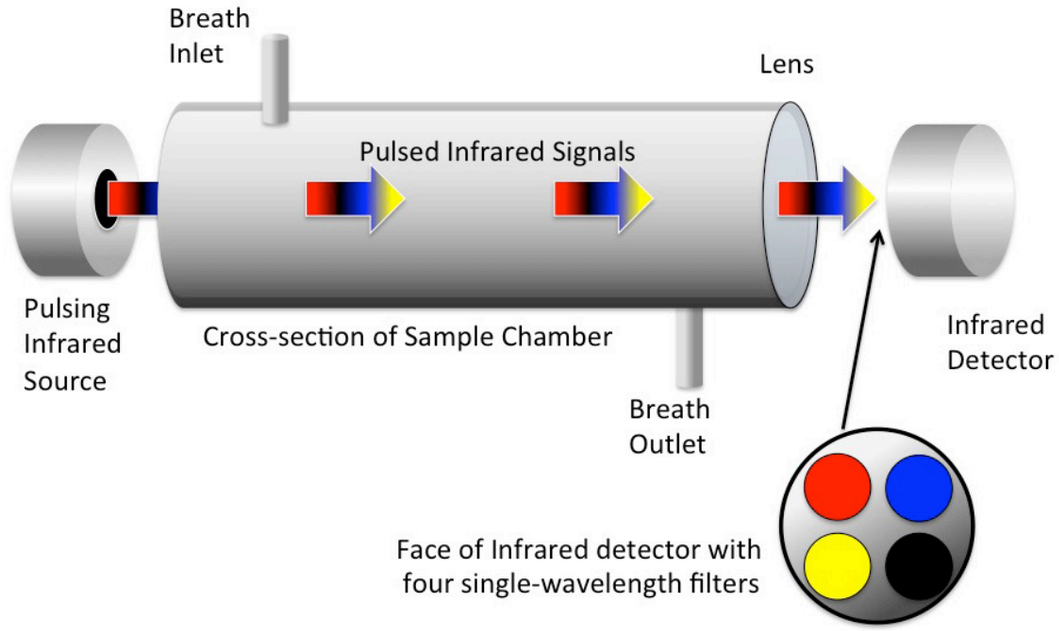


Figure 4 - Diagram of the optical bench of the Intoxilyzer 9000

Infrared Source

Another component of the Optical Bench is its infrared source. The Intoxilyzer 5000 used a halogen light bulb as its infrared source. The 8000 went to a pulsed infrared source, as apparently does the 9000, incorporating LEDs.

This is important in assessing the reliability of the Residual Alcohol Detection System. In the older 5000, the filter wheel component spun at around 1800 RPM. This meant that, for a ten second exhaled breath sample, about 300 readings were obtained from EACH filter. For the Model 5000EN, with five filters, this meant that 1500 discrete readings were obtained, analyzed and compared.

The Model 8000 moved from a Halogen light bulb and spinning filter wheel to a wire that was heated and cooled 4 times per second (4 Hz pulse). Only two filter points were utilized. That meant that the same ten second exhaled breath sample, only 80 discrete readings were obtained,

1 COPD - Chronic Obstructive Pulmonary Disorder

analyzed, and compared. As such, the so-called slope detector was less precise. Third-party testing indicated that the Residual Alcohol Detection System on the Model 8000 was less reliable than on the older 5000.

We simply don't know how the infrared source is implemented in the new 9000. The GBI reports the IR source is pulsed at 10 Hz. Without independent review, the veracity of the slope detector system cannot be verified.

Infrared Filters

In addition to the infrared source, the infrared filters provide a precise way to measure the ethanol concentration within the test chamber. The older Model 5000 had reported filter specification of 3.39µ (micron), 3.48µ, and 3.80µ, etc. CMI did not report the specific wavelengths used for the Intoxilyzer Model 8000, but we came to know that they were at 3.4µ and 9.36µ.

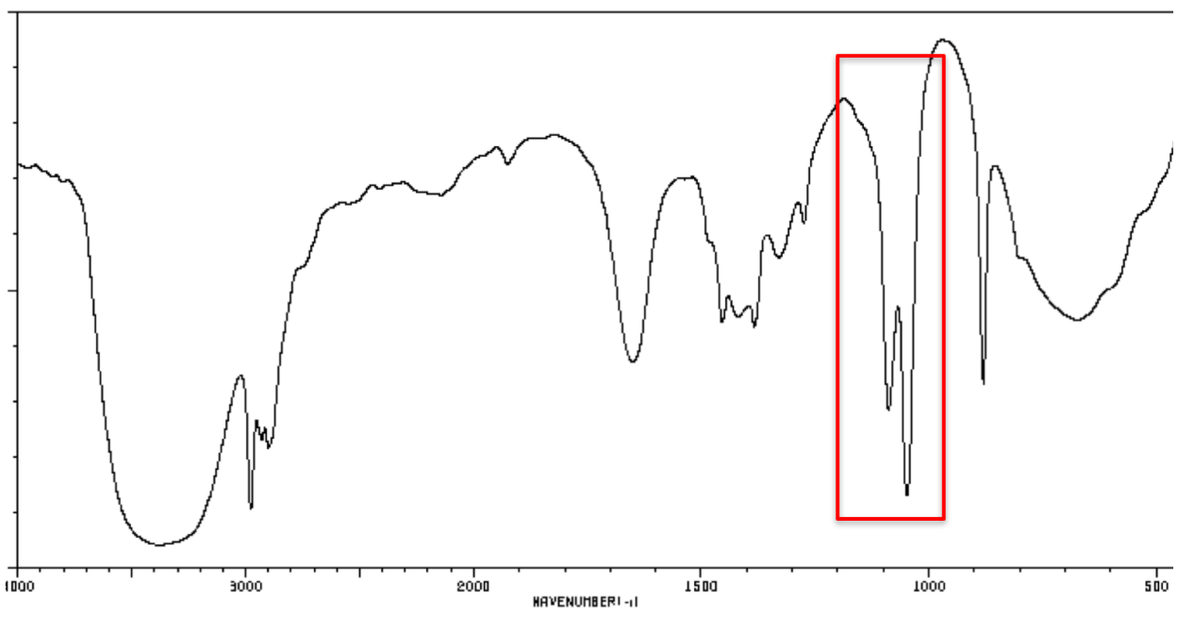


Figure 5 - The infrared region of detection for the Intoxilyzer 9000. The specific wavelengths have not been revealed. The bandwidth of the filters is unknown. How the software makes the comparison to determine the presence and quantity of ethanol in the sample is also undisclosed.

The 9000 filters are apparently somewhere greater than or equal to 8-microns, but less than or equal to 9 microns (≥8µ, but ≤9µ). Four filters are supposedly used, with undisclosed wavelengths and resolution. These specifications should be clearly stated.

The resolution of the filters is also important. IR filters are either narrow-bandwidth or wide-bandwidth. Think of this as narrow versus wide resolution. The wider a filter, the more IR light it absorbs. The narrow a filter, the more specific and precise it is at absorbing an IR energy bandwidth. This is important, as it speaks to the unit's *specificity* towards ethanol. The Model 8000 apparently had a tolerance to the filter of +/- .5 micron from target. This is too large, implies inherent measurement uncertainty, and can lead to false-positive readings. How does the 9000 compare in this regard?

Specificity for Ethanol

So, without knowing the specific bandwidth of the IR filters, we cannot reliably assess the overall specificity of the unit to read ETHANOL on the breath of the subject. Other substances, notably diethyl ether, and dimethyl sulfoxide (DMSO) and its metabolites can be found on the breath of human test subjects, and provide false positive readings on breath test devices that read in the 9-micron range. Again, only through independent testing of a variety of interfering compounds that create *substandard conditions* can we reliably assess the Intoxilyzer 9000's ability to ferret out interfering substances, and differentiate them from ethanol.

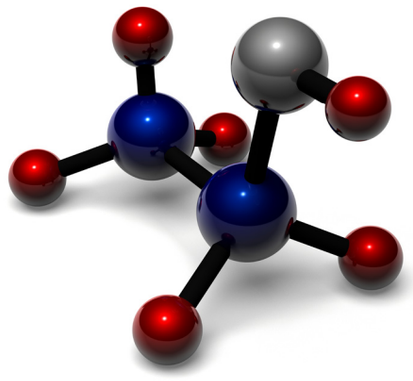


Figure 6 - The ethanol molecule

Analytical Software

Software drives breath alcohol testing devices. Without the software, the device is a huge, expensive paperweight. By understanding the software that drives the device, we understand how it is programmed to handle situations it encounters. What is the threshold at which it will report substandard ambient room air conditions? What does it do when it encounters such contaminated air? Does the unit subtract a measured amount for any anomalous conditions? How are readings reported, based on their apparent congruency? Are they truncated, then reported? Can a difference in two readings, .029 grams apart be reported (truncated) as two good readings within 0.02 grams?

There are dozens of conditions, all software driven, that we need to know and understand before we can assess the *reliability* of a device's reported readings. The Intoxilyzer 9000 has the potential to provide a great deal of information, particularly since it supplies a histogram – a graph – showing the exhaled air volume and the corresponding breath alcohol concentration. However, there needs to be a firm understanding of the information presented in that graph, particularly when some histograms seem to show anomalous readings that still appear to result in a device-reported "suitable" sample.

For more information on the Intoxilyzer 9000, see Mark Thiessen's article in Counterpoint, Volume 1, Issue 1, pages 31-39.

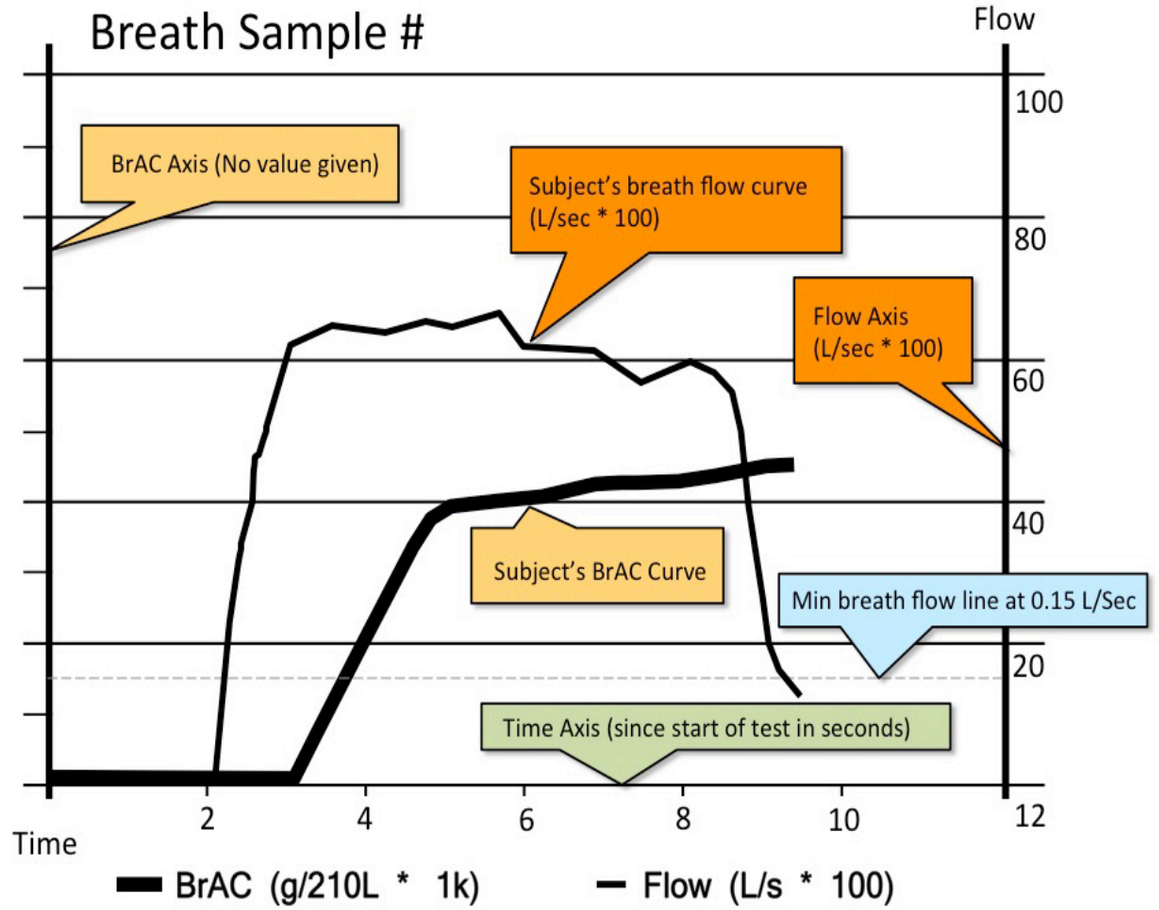


Figure 7 - The histogram of the breath sample in the Intoxilyzer 9000

Residual Alcohol Detection System (RADS) Algorithm[2]

To begin with, understand that it is exceedingly difficult to develop a Residual Alcohol Detection System (RADS) that properly and reliably detects mouth alcohol events. Interestingly, the histogram demonstrates how a rise or fall in one *measurand* (either the BrAC or the exhalation profile) can indicate that contamination is present. However, although instructive, the histogram is merely a representation of the numerical algorithm at work determining the results.

2 The Residual Alcohol Detection System is commonly referred to as a "Slope-Detector", as it analyses the *slope* of a BrAC profile to determine if residual mouth alcohol is present.

At its heart, the RADS is analyzing a BrAC profile as it is being introduced into the device. It compares the BrAC profile from one second to the next, looking for a sharp rise in BrAC, followed by a subsequent drop in reading. If the BrAC drops beyond a pre-programmed amount, the unit will flag the breath sample as improper – it contains alcohol contamination. We need to quantify the pre-programmed amount that the unit takes into consideration – How far does the BrAC reading need to drop? How far can the reading go up to begin with? Is this averaged? What algorithm is employed to make these calculations? What happens in the first five-seconds of the exhalation? Is this part of the profile taken into account? These issues will have major significance in cases where the subject is deemed, by the device, to be refusing to provide a breath sample.

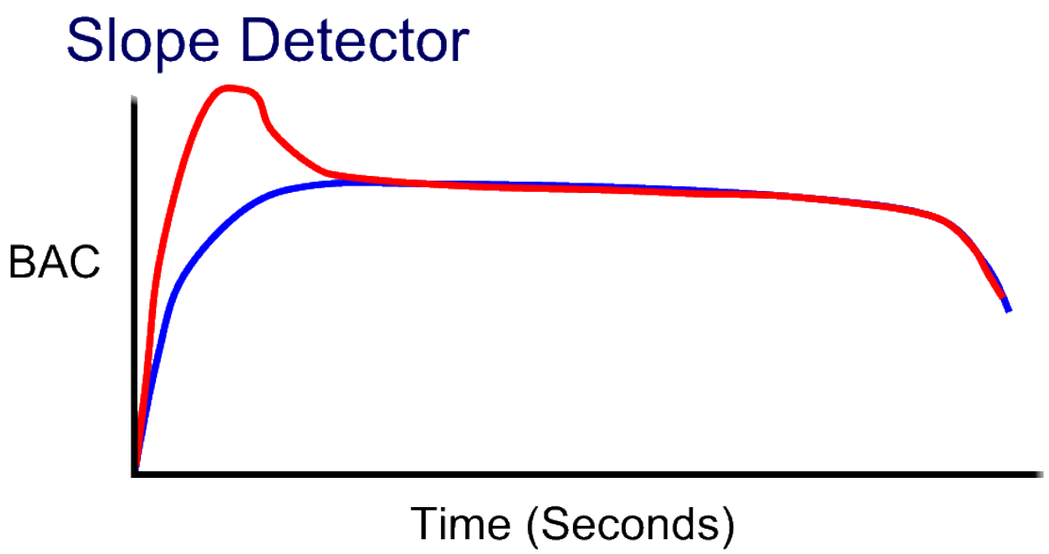


Figure 8 - What is the programmed algorithm in the Intoxilyzer 9000's Residual Alcohol Detection System (RADS)?

In some cases, individuals who have a mouth alcohol contamination level that does NOT exceed the pre-programmed amount will appear to the device to be NOT providing a suitable sample, WITHOUT indicating that some sort of substandard conditions are present. An individual may be incorrectly target by the device as "refusing to provide a suitable sample" merely because they have anomalous BrAC readings that DO NOT exceed the preprogrammed parameters created by some mouth alcohol contamination, possibly by a recent undetected burp, or medical condition such as GERD. Understanding the programmed algorithm will better provide a complete understanding of how the device determines the "suitability" of a sample.

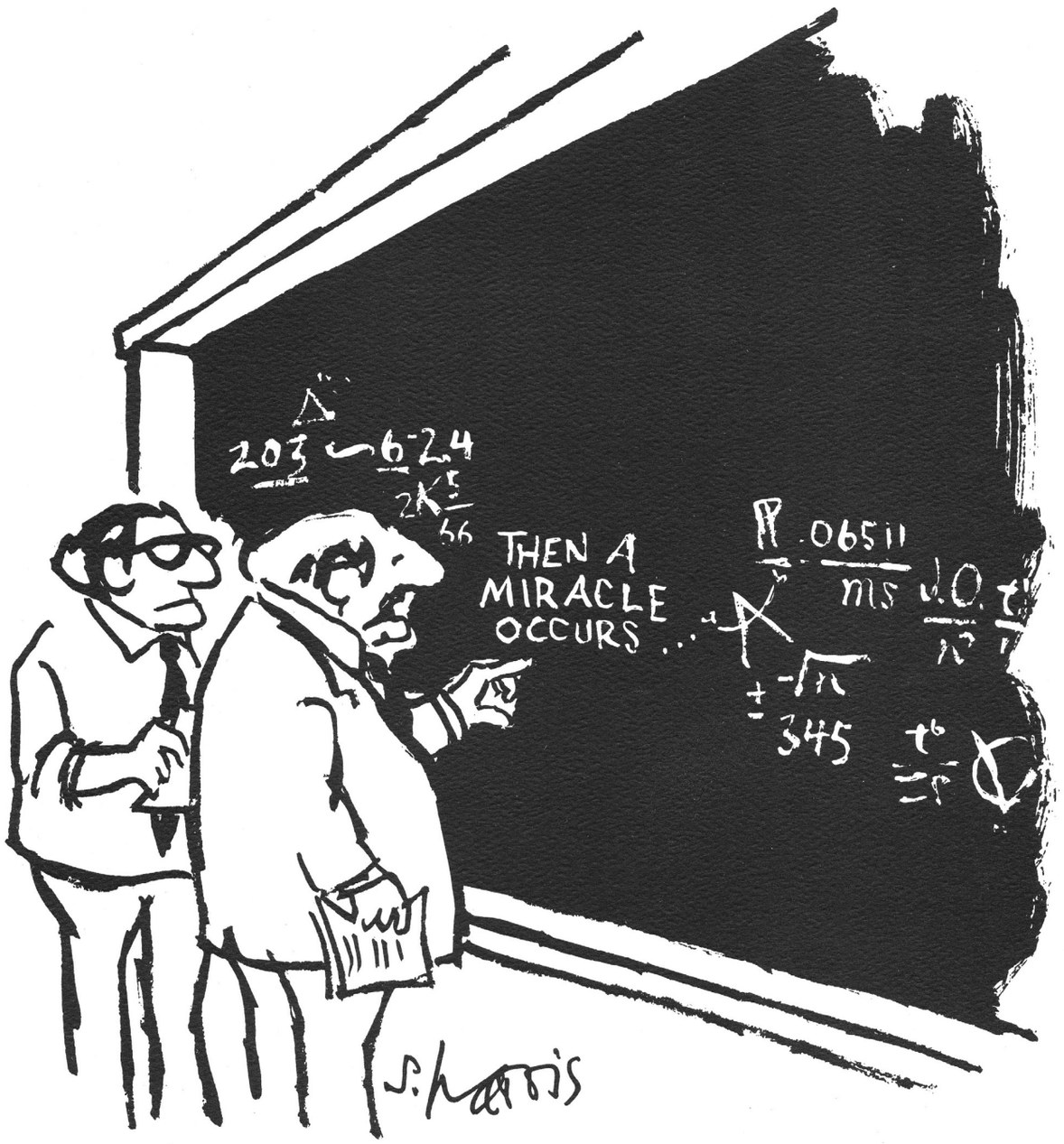
Administrative Software

The administrative component of the software is the "user-defined" part that is customized by the manufacturer based on the client's needs. Some jurisdictions use an ADCABA sequence that might occur only once, or be repeated twice, some an ADCABAWABA sequence in turn. Some jurisdictions allow the operator to bypass the sequence and grab a quick ABA sample. In some areas, the operator has absolutely no capacity to override the pre-programmed sequence.

Sample Breath Test Sequencing:

ADCABA	ADCABAWABA
Air blank	**A**ir blank
Diagnostic (internal)	**D**iagnostic (internal)
Calibration check	**C**alibration check
Air blank	**A**ir blank
Breath sample	**B**reath sample
Air blank	**A**ir blank
	Wait period (2-15 min)
	Air blank
	Breath sample
	Air blank

Program Algorithms?



"I THINK YOU SHOULD BE MORE EXPLICIT HERE IN STEP TWO."

More importantly, what role can the operator play in terminating the sampling process? In the Intoxilyzer Model 5000, the operator was able to generate an apparent refusal by pushing the START button during the sample, or immediately thereafter, generating an error message that appeared to indicate a refusal to provide by the test subject. Independent testing on the Intoxilyzer 8000 showed the device did not allow this situation to occur. What message occurs under the 9000 during this *substandard act*? Only independent testing will show us how this situation is handled and reported by the 9000.

Figure 9 - The START button on the Intoxilyzer Model 5000

External Calibration System

We know the 9000 can use either a wet-bath or dry-gas calibration standard. Does the dry-gas standard employ an altitude or barometric pressure correction system? This is important in areas, like Colorado, that have devices at altitude.

Internal Calibration & Diagnostic Software

The older Model 5000 was notorious for misreporting its readiness status. You could physically disconnect more than a dozen critical components in the 5000, and have it report "DIAGNOSTIC OK" upon boot-up. Additionally, both the 5000 and 8000 were supposedly able to correct internally for both processor drift (whatever that is) and sensor drift (calibration error of the lead selenide detector that generates the BrAC reading) when an internally generated artificial signal was put through the optical bench. Does the 9000 have similar capacity? What does it in fact do? Can the unit self-report component failure? Can the unit self-correct for component drift?

This becomes a more and more pressing concern as jurisdictions are starting the rely on the instrument in self-reporting its failure rather than taking the units out of service and performing annual maintenance. Unbelievably, annual maintenance, calibration, and correction is starting to disappear in Standard Operating Procedures in various jurisdictions. Therefore, we are relying on the integrity of the device to report when it is operating under *substandard conditions*. The potential for an individual device to provide inherently unreliable readings for months on end BEFORE it reaches a failure state could conceivably occur. We are relying on this internal diagnostic procedure, shown to be unreliable in older devices, to report when the unit is departing from factory specifications. Is this scientifically acceptable? Is this wise?

A Call for Transparency

The hallmark of good science is *academic peer review*. Adams publishes a study concluding condition X. Baker tries to replicate Adams' findings, is unable to do so, and concludes condition Y. Charles revisits Adams' work and determines that Baker made an error… etc. etc. etc.… The notion of reproducibility is at play here. We determine the reliability of a device or testing schema by producing results that are reproduced by independent testing and verification.

There can be no true scientific analysis performed – academically peer reviewed - with ANY breath alcohol testing device, whether the Intoxilyzer 9000 or any other, when access to the devices is limited to the prosecution ONLY. Private, or independent, review of the performance characteristics of the devices is crucial for, at least, the *appearance* of impartiality to be maintained. How is it that the CDPHE can destroy their own review data on a device, and still maintain the device is reliable? How can performance characteristics of an evidentiary device, its readings relied upon by the courts, be hidden from public scrutiny? ⚠

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Glossary of Terms

Accuracy

Refers to how close a measurement is to the true value of the thing being measured.

> **NOTE:** Many scientists and researchers in the scientific and medical community use the terms accuracy and validity interchangeably. There is considerable argument that this is a poor and imprecise use of language that should be rectified.

Air Blank

A system test performed by a breath test device on the ambient or room air. The purpose of an air blank is twofold:

- To purge any residual contamination from the sample chamber of the breath test device;
- The test the ambient or room air to ensure that it is free from any potential contaminants that would create a false-positive reading. See Ambient Fail.

Air blanks are performed a number of times during a breath test sequence.

Ambient Fail

An error-message received in breath alcohol testing when the device analyses a sample of room air prior to receiving the test subject's breath sample, and determines that sub-standard conditions exist. See Air Blank. If the room air has an infrared absorbing substance in an amount that exceeds a programmed threshold, the device responds with an Ambient Fail error message. This indicates that some substance in the room air is volatile, and capable of absorbing infrared radiation to an extent that the breath test results would be adversely affected.

An Ambient Fail error message may be the result of an inadequate purge of contaminated air at the end of any previous breath testing sequence.

The operator may elect to re-start the testing sequence to see if the error is cleared. If the error message re-occurs, it indicates that an unknown substance is absorbing infrared radiation at the same wavelengths employed by the analytical component of the device, and the testing conditions are sub-standard. Testing cannot be conducted under these conditions.

Breath Sample

A sample of exhaled breath from a test subject that is received directly into a breath alcohol testing device. See Suitable Sample to discuss the required parameters of the breath sample.

Breath Test Sequence

There are a number of required components to complete a breath test:

- Air Blank
- Breath Sample
- Calibration Check
- Internal Diagnostic
- Operator Input
- Standards Check

Calibration Check

To compare a measurement against a known standard WITHOUT correcting the result to its true value.

GERD (Gastro Esophageal Reflux Disease)

Gastroesophageal Reflux Disease, or GERD, occurs when the lower esophageal sphincter (LES) does not close properly and stomach contents leak back, or reflux, into the esophagus. The LES is a ring of muscle at the bottom of the esophagus that acts like a valve between the esophagus and stomach. The esophagus carries food from the mouth to the stomach. If the stomach contents contain alcohol a Fresh Mouth Alcohol error may occur.

Interferent

A substance that has chemical or physical characteristics that makes it virtually indistinguishable from the substance being tested; A chemical compound other than the substance of interest. In alcohol testing, an interferent refers to any substance capable of being in the blood or urine, or found on the breath of a test subject that has measurement characteristics similar to ethanol, giving rise to falsely elevated results. The interferent may or may not have intoxicating properties, and may be found as a naturally occurring substance, or introduced either by accident or design to the test subject, as with occupational exposure. See *Specificity*.

Measurand

The term measurand simply to the physical quantity, property, or condition that we want to measure. Note that we are NOT talking about the thing itself, but rather, its physical quantity, property, or condition. Examples include: 5 seconds, 5˚Celsius, 5 pounds or kilograms of an item, etc.

Optical Bench

The Optical chamber, often referred to an as Optical Bench, consists of a chamber, tube or pathway in which both a room air, wet-bath solution or dry-gas calibration standard, or exhaled breath sample are analyzed. Light or heat energy will also pass through the air, gas, or breath sample to determine the presence and concentration of ethanol in the sample.

Precision

The reproducibility or repeatability of a measured result. Precision is the degree to which a calculated central value (for example, its mean) varies with repeated sampling. A narrow variation in the measurement means a more precise value in the measurand.

Reliability

Refers to the accuracy, consistency & stability of measurement across situations. Reliability refers more to the process in coming up with the measurement than the actual measurement itself.

Residual Mouth Alcohol

Also referred to as Fresh Mouth Alcohol. Contamination in the mouth or oral pathway caused by the recent consumption of alcohol, OR; by recent regurgitation, belching, or burping of alcohol or alcohol vapors from the stomach; The alcohol produced by a test subject that comes from anywhere but the deep lung alveolar sacs of the subject.

Studies show that contamination of alcohol in the mouth or oral pathway takes 12-15 minute to dissipate naturally. Some alcohol contamination can linger for longer periods of time due to being trapped by dental appliances or pockets in the gums. Detection algorithms in evidentiary breath alcohol testers may not efficiently identify contamination of a breath sample by fresh mouth alcohol.

Perhaps the two terms should be separated as follows:

- *Fresh* Mouth Alcohol will refer to alcohol contamination in the oral pathway due to recent consumption of alcohol or regurgitation of alcohol vapors from the stomach; a present source of contamination.
- *Residual* Mouth Alcohol will refer to alcohol contamination in the mouth or oral pathway, from whatever source, that requires time to dissipate and be naturally eliminated; a lingering source of contamination that is reduced over time.

Sample Chamber

The component of an analytical measuring device where the sample is either collected, or actually analyzed. In a fuel cell device, the sample chamber is used to collect a known volume of air before being sent through to the fuel cell for chemical reaction and measurement of alcohol levels. In an infrared breath testing device, the sample chamber contains the breath sample itself, while infrared energy is "beamed" through the sample using infrared spectroscopy as an analytical tool.

Some sample chambers are very small – perhaps a millilitre or so in volume. Fuel cell devices typically use a very small sample chamber. Some are larger, with volumes of 50-80 millilitres, typically found in the original Breathalyzer, and current infrared evidentiary devices.

Some are simple tubes with a direct flow through path. Some are "folded" and incorporate mirrored surfaces to bounce the infrared light through the sample, with the manufacturers hoping to increase the sensitivity and therefore the accuracy and reliability of the device.

Specificity

Properly referred to as Analytical Specificity. Specificity is the ability to analyze for solely a particular substance; the property of a method to determine only the desired compound it purports to measure and without responding to any other substances that might be present in the test sample. In alcohol testing, specificity generally refers to the ability of an instrument to accurately measure the concentration of ethanol in a blood, breath or urine samples, and to differentiate or identify any other competing substances. See Interferent.

Truncation

The process of rounding down a reading to its next lowest multiple of ten. For example, a BAC of 128mg/dL would be expressed as 120mg/dL. A reading of 89mg/dL would therefore become 80mg/dL. Truncation is performed in certain jurisdictions, while actual value readings are used in others.

Suggested Reading & References

CMI, Inc., *Intoxilyzer 9000 Operator's Guide*, 2008.

Colorado Department of Public Health and Environment, *Intoxilyzer 9000 Operator Guide for Law Enforcement,* Version 1.1, Sept 2013.

GBI Crime Laboratory, *Evaluation of Breath Alcohol Testing Instruments to Replace the Intoxilyzer 5000*, September 2012.

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