

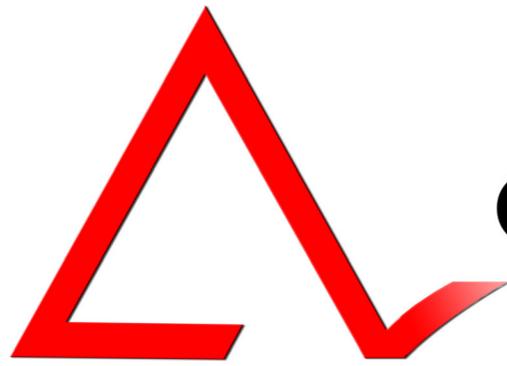


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The Journal of Science and the Law

*Free Introductory
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The Journal of Science and the Law

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Infrared Spectroscopy

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3

An Introduction to DUI Investigations

An overview of one of the most common events in the criminal justice system. A quick look at some statistics, and what you really need to know to manage one of these cases.

4

Fuel Cell Basics

Thousands of tests are performed each day using portable breath alcohol testers. What is their underlying science?

Regular editions will include:

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- News & Happenings / Upcoming Events & Seminars
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- Scientific article reviews
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Welcome

The curse of knowledge

As professionals, we become more and more focused in our specific knowledge subsets. As we become specialists, our way of looking at our professional field narrows. Our language and our thought patterns also shift. We quickly lose sight of the fact that we are incomprehensible to others who are NOT part of our group of specialists. We speak to one another using the jargon, acronyms, and terminology of our cohort, and converse easily with others within our field. To anyone outside our chosen profession, we are indecipherable. We speak a different language. This is the curse of knowledge.

Lawyers speak the language of the law, while scientists use terminology that often differs greatly. For a member of one group trying to understand the writings or lectures of the other group, a barrier is present. The curse of knowledge has created a wall, where one group cannot find intersecting terminology with the other.

I speak from first hand experience. For about a decade I've been successfully teaching technical and scientific issues to lawyers. I cannot begin to count the number of times that a lawyer, intelligent and successful in their field, fully conversant in the legal world and the language of their profession, have approached me - panicked that they will not be able to grasp the science behind our program. It usually starts with an admission, expressed in a hushed tone while looking over their shoulder in a hope for anonymity, whispered along these lines: *"I sucked at chemistry in high school... That's why I became a lawyer!"*

"I sucked at chemistry (or physics, or biology) in high school.... That's why I became a lawyer..."

If you have just nodded your head, or said to yourself, *"Oh, Ya!"* then you are in the right place¹. If you have ever tried to decipher the indecipherable jargon in the forensic or scientific article that you MUST understand in order to do your job diligently, then you are in the company of others reading this article. Don't worry; we will get through this journey together, one step at a time.

Welcome to Counterpoint.

Counterpoint – The Journal of Science and the Law

This quarterly online journal features articles that offer clear and concise explanations on various technical or scientific issues to legal professionals. Any scientific, technical or forensic area that you might encounter is open for examination, from the basics of DUI breath testing, to a more advanced understanding of gas chromatography and blood analysis. *The articles are designed to be read in under 20 minutes each.*

¹ Let's be fair. I also discuss legal issues with scientists, who often complain that they cannot understand the nuances of legal terminology, the elements that form a criminal statute, or the meaning behind a legal order.. The curse of knowledge is a two-way barrier.

Together, we will examine issues in general forensic science, accident investigations, crime scene analysis, fingerprints, and polygraphs... in short, anything and everything that impacts you in the courtroom based on something originating in the lab or out in the field will be open for examination, discovery, and mastery. To that end, we will be establishing a *Professional Learning Community* for legal professionals.

Creating a Professional Learning Community

The goal of a *Professional Learning Community* (PLC) is to promote professional development for a common goal. A PLC is meant to foster and mentor ALL participants to better themselves in their respective field through extended learning opportunities. Again, the online journal becomes a core component precisely because it supports and promotes continuing educational efforts for the subscriber.

Content will include articles from experts in their respective fields, including both scientists and lawyers. The journal will focus on disseminating news that is both current and relevant to your practice. Subscribers will then have access to continuous ongoing information in the online journal, access to videos and custom-authored online training programs, and access to a library of past titles.

More importantly, subscribers will be able to pose questions to authors, contributors and other participants in the online classroom component, and interact with content experts. We will have created a Professional Learning Community dedicated solely to enhancing the experience of the subscribers, focusing on implementing information into your practice in a meaningful way. We see the journal content, online training content and any optional seminar content intrinsically linked in order to provide an enhanced learning opportunity for participants. Each supports the other in providing learning opportunities.

Please read Susan Rechny's article in this issue on creating a *Professional Learning Community*. It provides the educational

background for what we will accomplish together. The journal, online classroom and optional mLearning packages are designed for optimal educational validity, cohesiveness and collaboration.

Counterpoint-Journal.com

Our new website is www.counterpoint-journal.com. This will be the portal that you will access to download the journal, participate in an optional online classroom discussion if you desire more information or interactivity in a specific subject, and to optionally download and complete mobile learning packages.

Here is a graphic model of how the system works:

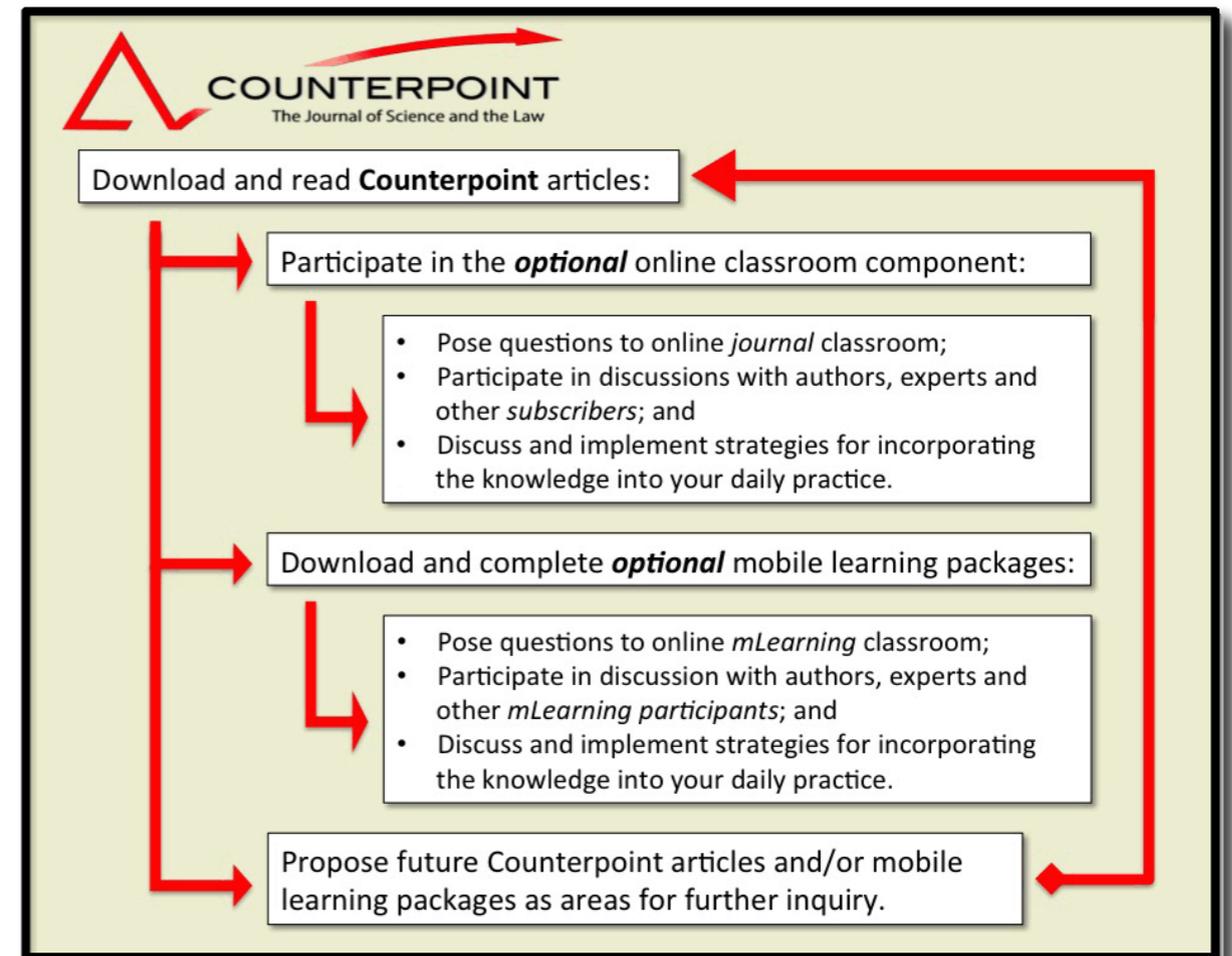


Figure 1 – Flowchart of the Counterpoint learning model

Electronic Learning Packages (and Mobile Learning Packages)

eLearning vs. mLearning

The journal and *mobile learning* packages are authored so that they are accessible in multiple formats, from traditional desktop learning for both PC and Mac systems to formats that allow access via Tablets or iPads, and smartphones. This transforms the electronic learning module (eLearn) into a *mobile learning* (mLearn) platform. This makes the information accessible anytime, anywhere. You could conceivably complete a module at lunch, in the subway during a commute, or the hallway outside court. *The modules are designed to be completed in under 30 minutes each.*

The information will be made accessible on demand, as required to fulfill immediacy for the learner. Studies have shown that, of those who can access mobile learning, 75% of learners praise the convenience and time management benefits of mLearning. Mobile appliances such as tablets, iPads and smartphones have made mLearning ubiquitous. We will change the notion of immediate access to critical information from eLearning to *mLearning*.

The journal is intended for BOTH new and seasoned legal professionals. Articles are written for multiple levels of background understanding. Although some of the articles may appear as if they are presenting rudimentary material, we feel it is important to go through the information section by section, ensuring that you have mastered the information in each article. If you are well-versed at a specific subject you will still gain understanding by reviewing what otherwise appears to be an article aimed at a newcomer. If this is fresh material, take your time to digest the new information. Ask questions in the optional online classroom, and know that you can conquer the “curse of knowledge”.

So, welcome to Counterpoint. I hope you will see the value of the material, the value of participating in the journal, and knowledge mastery from your investment of time and collaboration. Please, look through this sample issue, and subscribe for the first year of what we hope will be an ongoing subscription. It has been shown time and again that your success is tied to active engagement in ongoing professional development.

I look forward to a mutually enriching experience of collaboration, and of your participation in this professional learning community.



Jan Semenoff
Editor-in-Chief

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The Standard Drink



In Brief:

This article introduces the mechanism of absorption, distribution, metabolism and elimination of ethanol. We discuss the different volumes, types, and concentrations of ethanol in alcoholic beverages. This article is important as it sets the ground work for future: Investigations into the mechanics of absorption; Issues in calculating ethanol concentrations at a specific point in time; Specificity towards ethanol; and the effects of body mass and gender.

To a toxicologist – it’s all about the dosage. Dosage refers to the measurable quantity of a substance that a subject receives. The Swiss Renaissance physician, Paracelsus, is widely regarded as the founder of the field of toxicology. He famously wrote, “*The dose makes the poison.*” In other words, a glass of wine or two enjoyed in a lingering fashion over dinner presents a very different toxicology profile to the consumption of 18 Boilermakers over a six-hour period at a frat party. One profile should present no toxicological issues, while the other is likely fatal.

Ethanol versus Alcohol

Let's start off with an important distinction. The "alcohol" we drink should be properly referred to as *ethanol*. The generic term *alcohol* refers to the group of compounds in the "alcohol" family – methanol, ethanol, isopropanol, butanol, etc. The alcohols are organic hydrocarbon molecules with an Oxygen-Hydrogen (O-H), or *hydroxyl functional group*. *Upcoming articles will focus on the chemical properties of ethanol, as we need to understand these characteristics in order to understand how breath test devices work, and how the ethanol moves through the human body. We will also look at the interferent effect of these other alcohols, but for now, we will concentrate on ethanol.*

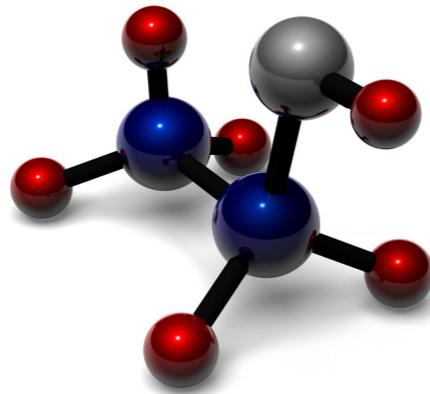


Figure 1 – "Ball & Stick" representation of an ethanol molecule

At the outset, you also need to know that ethanol is a metabolic poison, and your body goes to great lengths to remove this toxin. If ingested in high doses, it takes less than 500 millilitres of pure ethanol to kill an average size human. Even under normal conditions, the process of ridding the body of ethanol produces toxic byproducts itself. As your body eliminates the poison, it suffers the side effects of the toxin. You don't need to suffer an hangover to experience these negative side effects.

First, your body metabolizes the ethanol into *acetaldehyde*, the chemical responsible for hangover symptoms, among other things. Your body will eventually convert the acetaldehyde into *acetic acid*, the key ingredient in common household vinegar. *When people say they are getting pickled, it's not far from the truth.* Eventually, the acetic acid is metabolized into carbon dioxide and water. *More on this process in three upcoming articles discussing the Absorption, Distribution, and Metabolism of ethanol.*

Biologists have come to believe that consumption of ethanol may be an adaptive process among humans, occurring over the millennia. The ability to metabolize the alcohols found in fermented fruit shows up in our enzymes about 10 million years ago. The earliest known discovery of ancient pottery jars in northern China shows the residue of a fermented grape, berry, honey, and rice beverage. This dates back to about 7000 BC, about the time when fermented beer and grape wine were being produced in the Middle East. In the European Middle Ages, low-yield wines and beers were common beverages for all classes and ages of people.

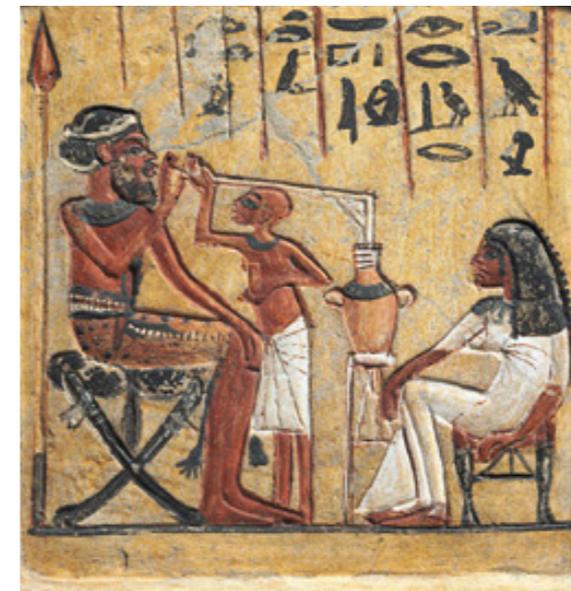


Figure 2 – Egyptian brewing, circa 1500 BC

In fact, during that period of time, consuming these low-yield ales and wines was perhaps beneficial. Drinking local stream or well water, often contaminated with bacteria due to poor sanitation, gave rise to such diseases as Cholera, Listeria and Botulism. Keep in mind that the production of low-grade alcoholic beverages involves both *boiling* the water, and *fermenting* the grains or fruit into ethanol. The resulting ales and wines were, in effect, pasteurized and laden with disinfectant.

Humans and Ethanol

The main enzyme responsible for eliminating ethanol is called the *Alcohol Dehydrogenase Enzyme*, or ADH. In humans, ADH production does not begin until after birth, and only matures after years before reaching adult levels.¹ The ADH enzymes are found in the linings of the stomach and the liver. Our bodies create 6-9 different forms of alcohol dehydrogenase, each with slightly different properties. Their sole function is to rid the body of ethanol.

The following chemical reaction occurs:



(Ethanol + ADH → Acetaldehyde + [Acetaldehyde dehydrogenase] + Hydrogen)

The acetaldehyde (chemically, also referred to as *ethanal*) is *more* toxic than ethanol, and is responsible for your hangover symptoms. In fact, acetaldehyde is a highly reactive and flammable liquid that is also volatile. Volatile, in the chemical sense, means that it can evaporate at room temperature. The acetaldehyde is then broken down by Acetaldehyde Dehydrogenase into acetic acid. Finally, the acetic acid is broken down, giving off water and carbon dioxide as the final metabolites of the process.

¹ Faassen, E and Niemelä, O., Biochemistry of prenatal alcohol exposure, NOVA Science Publishers, New York 2011.

ADH & Elimination of Ethanol

For most people, the levels of ADH remain constant throughout their lives. Chronic alcoholics, however, have been studied to show that their ADH levels *increase* as their bodies' respond to incessant metabolic poisoning. This may account for their faster degree of metabolism of alcohol. While the typical person has an alcohol elimination rate varying between 0.013 – 0.018 grams BAC per hour², British researchers found that chronic alcoholics may eliminate alcohol by 0.020 – 0.040 grams BAC per hour. Once the metabolic stress of alcohol consumption is reduced, the ADH levels of these persons may return to normal values over time.

Studies also indicate that the ADH enzyme levels vary between individuals based upon racial or hereditary factors. A person may be less able to metabolize alcohol due to lowered levels of one or more of the ADH enzymes. This trait may be passed down from generation to generation. Persons of Pacific Rim heritage, North and South America's Indigenous peoples, and Australian Aborigines have been shown by some researchers to have lower overall levels of ADH in their bodies (*beginning with Fenna et al, 1971*).

This finding is in dispute (*Bennion & Li, 1976, Lee et al, 1999*). Some researchers believe that the levels of ADH are an adaptive process, as few of these cultures had any comparable history of alcohol production or consumption prior to its introduction by European settlers.



² The total amount of ethanol broken down per hour is estimated in the range of 0.1-0.3 grams per kilogram body weight per hour. This is usually translated into 6 – 9 grams of ethanol per hour for a healthy subject. This is usually estimated at .013 - .018 grams/100 mL per hour subtracted from the BAC.

The Standard Drink

What constitutes a “*standard drink*” varies from country to country, with no agreed upon definition. The volumes served vary in different government regulations. As an example:

Australia	10 grams (ethanol total dosage)
Canada / US	14 grams
Hungary	17 grams
Japan	20 grams

In general, the standard measure for how much ethanol is contained in a beverage alcohol drink is defined as the number of millilitres of pure ethanol present in 100 millilitres of the beverage, at standard room temperature, or 20 °C (68 °F)³. This determines the Alcohol by *Volume* (ABV, abv, or alc/vol). There is a formula to do this...

However, in North America, it is common to express alcohol percentage as Alcohol by *Weight*, or ABW. There is also a conversion formula for this calculation, but you don’t need to worry about it....

Why are we concerned about “Standard Drinks”? We need to be able to quantify the ethanol consumption in order to make meaningful comparisons and calculations. Each North American Standard Drink (SD) will deliver about 0.6 ounces (or 14 grams) of ethanol in total dosage of ethanol.

This, in turn, produces the equivalent Blood Alcohol Concentration (BAC) of about 0.02 grams (20 mg)/100 mL of blood for a 190-lb male, on average.

³ In order to have a standard reference condition in chemical equations, NIST (The National Institute of Standards and Technology) created a condition known as STP. This is an acronym for Standard Temperature and Pressure. The standard temperature is comfortable room, or laboratory, temperature of 20 °C (68 °F) and a standard ambient air pressure equal to sea level – 1 Atmosphere or 14.7 psi (pounds per square inch).

Common alcoholic beverages run at the following average ethanol concentrations:

Beer	4-6%	(some are between 2-15%)
Wine	12-14%	(some are between 9-16%)
Port	15-20%	(some are between 9-30%)
Whiskeys	40%	(some are between 35-70%)

These beverages are typically served in different volumes:

Beer	12 ounces	(341ml)
Wine	5 ounces	(142 ml)
Port	3 ounces	(85 ml)
Whiskeys	1-½ ounces	(43 ml)

So, North American “Standard Drinks” deliver the following ethanol levels:

Beer	12 oz @ 5%	= 0.6 oz (14 g) of 100% ethanol
Wine	5 oz @ 12%	= 0.6 oz (14 g) of 100% ethanol
Port	3 oz @ 20%	= 0.6 oz (14 g) of 100% ethanol
Whiskeys	1.5 oz @ 40%	= 0.6 oz (14 g) of 100% ethanol



Elimination of Ethanol

We know that average *elimination*, on the other hand, is for the most part, between 0.008 – 0.025 grams per hour. This gives us the rough guide of about “a drink per hour” for most people (*well, actually 1.25 hours*). Many toxicologists use an average of 0.015 – 0.017 grams per hour for computations. However, the elimination rate value has been reported from 0.09 – 0.045 grams per hour. It is important to remember that without testing an individual subject, we just don’t know what their specific elimination rate will be.

More problematically, a person’s elimination rate can vary from time to time; determining an absolute elimination rate value for a person is probably not possible. Some toxicologists will perform calculations using both the high and low elimination value, often resulting in a situation where the calculation results in a series of readings that straddles the legal limit. Many researchers suggest that these retrograde extrapolation calculations are little more than an educated guess. Again, we will delve into this area in greater detail in the future.

The problem is keeping track of consumption. Most people don’t count their drinks. Some will refresh their beer from the pitcher, and totally lose track of their actual consumption. Alcoholic beverages can vary in proof⁴, or concentration among brands. We also have the issue of consumption patterns. Some people discount the beers they had earlier in the day as not affecting them; some people will forget the shooters that finish the night just prior to driving home.

⁴ The term proof is derived from the early frontier practice of testing the whiskey sold to make sure it wasn’t watered down. A sample of the whiskey was mixed with gunpowder and ignited. If the whiskey burned with a steady blue flame, it was “proof” that the whiskey was good. In general, proof equals twice the alcohol concentration in w/v%. For example, 80 proof whiskeys contain 40% ethanol by weight per volume.

Drink Type	Ethanol Concentration weight / volume %	Drink Size to Produce a Dosage of 0.6 ounces (14 grams) ethanol	
Beer – Regular	≈ 5.0%	12.0 oz.	355 mL
Beer – Light	≈ 4.2%	14.0 oz.	415 mL
Beer – Ice	≈ 5.5%	11.0 oz.	325 mL
Beer – Malt Liquor	≈ 6.5%	9.0 oz.	265 mL
Beer – Fortified	≈ 9.5%	6.0 oz.	180 mL
Wine – Regular	≈ 12.0%	5.0 oz.	150 mL
Wine – Sparkling	≈ 12.0%	5.0 oz.	150 mL
Wine – Fortified	≈ 18.0%	3.5 oz.	100 mL
Distilled Spirit – 80 Proof	≈ 40.0%	1.5 oz.	45 mL
Distilled Spirits – 100 Proof	≈ 50.0%	1.0 oz.	30 mL
Liqueurs and Cordials	≈ 7.0%	2.0 oz.	60 mL
Coolers	≈ 5.0%	12.0 oz.	355 mL
Prepackaged Cocktails	Vary	???	???

The symbol ≈ Means, “approximately equal to.”

Source: International Center for Alcohol Policies (ICAP). *What Is a Standard Drink?* ICAP Reports No. 5. Washington, DC: ICAP, 1998.

Table 1 - Standard North American drink types

If a 190 lb. male goes to a bar, as an example, and quickly downs a couple of standard drinks, and then slows down his consumption to a drink every 45 minutes or so, his initial BAC will be rather high, based on the first few drinks. Even slow consumption after that will maintain the initial high BAC, due to the combined efforts of slow consumption, and elimination.

An estimated BAC at the *end* of the first hour would be:

$$\begin{array}{r}
 2 \text{ Standard Drinks @ } 0.020 \text{ grams per drink} \quad \approx 0.040 \text{ grams} \\
 \text{Subtract 1-hour worth of elimination} \quad \quad \quad \underline{- 0.015 \text{ grams}} \\
 \text{BAC} \approx 0.025 \text{ grams}
 \end{array}$$

The Effect of Drink Sizes

In some licensed establishments, a Standard Drink is served⁵. Consumption at home, on the other hand, probably does not produce a Standard Drink. Few people measure the rum in their cola at home, and pour substantially stronger drinks than standard. If the subject has honestly consumed only “a couple” – meaning two drinks, but they contained 3 ounces of whiskey each, then each drink has delivered about 0.04 grams instead of the expected 0.02 grams. In short, they haven’t had two drinks.... *They’ve had the equivalent to four Standard Drinks.*

⁵ Some establishments offer the “club size”, doubling the alcohol content for a dollar or so more. Some bars pour martinis that are the equivalent to 3-4 standard sized drinks. I’m concerned that this double, triple, or quadruple drink is not taken into account when a person self-assesses the amount they’ve consumed in an evening. *Two generous martinis could be equivalent to 8 Standard Drinks...*

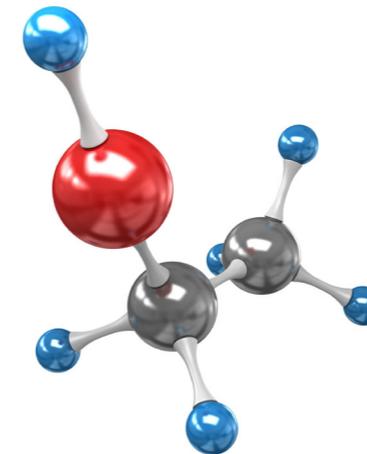
If the first two heavy drinks deliver 0.04 grams each, and are consumed in an hour, we would have a corresponding BAC at the end of that hour as follows:

$$\begin{array}{r}
 2 \text{ NON standard drinks @ } \approx 0.040 \text{ grams per drink} \quad \approx 0.080 \text{ grams} \\
 \text{Subtract 1-hour worth of elimination} \quad \quad \quad \underline{- 0.015 \text{ grams}} \\
 \text{BAC} \approx 0.065 \text{ grams}
 \end{array}$$

If the subject slows their consumption to just one truly standard drink per hour, then after three more hours, they are approaching the legal limit. Real world consumption patterns dictate actual BACs, unlike the controlled experiments conducted with test subjects in the lab.

The Effect of Ethanol Concentration

Of course, this assumes a standard ethanol concentration. If the subject consumes three standard SIZE beers, but the beers contain a 9.5% concentration of ethanol (as opposed the standard 5%), then the person has consumed the equivalent of almost 6 Standard Drinks. More and more, the ethanol concentration of some fortified beers on the market are increasing beyond the typical 5% beverage. Similarly, a single shot of 80% rum (160 proof) is equivalent to two standard drinks.



The Effect of Body Mass

What happens to persons of different body weights? Let's pretend three men are having a beer at a BBQ, and the beers are the same – 12 ounces at 5% ethanol concentration. But, one guy weighs 150 lbs., the second weighs 190 lbs., and the third weighs 240 lbs.:

Weight & BAC Equivalent from 1 Standard Drink:



Weight	150 lb.	190 lb.	240 Lb.
BAC	0.025 g	0.020 g	0.015 g

Final Thoughts:

As Paracelsus taught us 500 years ago, it's all about the dosage. Understanding the concept of the Standard Drink is important because it gives us a common language to use to describe and quantify effective dosages of ethanol among different subjects. When we explore issues in absorption and distribution of ethanol, this concept will become important. During the articles focusing on *Retrograde Extrapolation*, *Anterograde Extrapolation*, and the *Pharmacokinetics of Ethanol*, the concept of *dosage* will be critical. ▲

More to Explore:

Carrigan, M, Uryasev, O, *et al.* Hominids adapted to metabolize ethanol long before human directed fermentation; *PNAS*, 2014; *Vol. 112, No 2*, pages 458-463.

Klaassen, C.D. (Editor), *Casarett & Doull's Toxicology: The Basic Science of Poisons*, 7th Edition, McGraw-Hill, 2008.

Lee, J.F., Lu, R.B., *et al.*, "No association between DRD2 locus and alcoholism after controlling the ADH and ALDH genotypes in Chinese Han population", *Alcohol Clin Exp Res.*, 1999, Apr, 23(4), pages 592-599.

The Effect of Gender

Body mass index differences, body fat percentage differences, and the different types and efficacy of ADH enzymes between males and females all work together to create a unique profile of ethanol absorption and metabolism¹.

For more information on this issue, and to see how body mass and body fat differences play an important role, please see the optional mLearning package, "Exposing the Myths Surrounding Alcohol"



¹ The version of alcohol dehydrogenase in women is less effective than that in men, which is part of the reason that women have a lower tolerance for alcohol than men. Women also have a higher body fat percentage, on average, which means the alcohol consumed will be dispersed in less tissue with water, resulting in a proportionately higher BAC. This will be discussed in detail in both this quarter's optional mLearning package, and an upcoming article of ethanol metabolism in humans.

Glossary of Terms

Alcohol – Alcohols are, by chemical definition, a string of hydrocarbons (C-H; carbon-hydrogen bonds) with a hydroxyl (O-H; oxygen-hydrogen) attachment. There are different forms of *alcohol*, each defined here separately. Window cleaning solution, mouth freshener, after shave products and other disinfectants, used by some as intoxicants, contain different forms of alcohol.

Alcohol Dehydrogenase Enzymes- The *alcohol dehydrogenase enzymes* (ADH) are enzymes found in the linings of the stomach and the liver. Our bodies create 6-9 different forms of alcohol dehydrogenase, each with slightly different properties. Their sole function is to metabolize alcohols. They are believed by some researchers to be genetic traits, with lower levels reported among different ethnic groups, although this is in dispute. They take years to mature in humans. Males and females have different types and quantity of ADH enzymes.

BAC – *Blood Alcohol Concentration*, typically expressed in milligrams of alcohol per 100 millilitres of blood. This is a legal measurement of alcohol concentration in the bloodstream, determining whether a person is considered legally impaired. This is a measurement of “weight by volume” (w/v). 0.100% w/v is equivalent to 100 milligrams of alcohol per deciliter (100 milliliters) of blood, which is the same as 1 gram per liter (g/L). In Canada, a BAC of 80 mg/100 mL is the maximum allowable by law, with any excess thereof a criminal event.

Internationally, blood alcohol levels are often stated in millimoles per liter (mmol/l). 1 millimole per liter is equal to 4.61 mg/dl or 0.00461% w/v. In the other direction, each 0.01% w/v is equal to about 2.169 mmol/l.

In the United States, this concentration is often expressed in grams alcohol per 100 ml, or grams alcohol per 210 litres of breath. Most states use 0.08 grams alcohol per 100 ml blood as the legal limit, although some have lower levels used for different presumptions. From this expression we get the generic “.08” term.

B_rAC – A term that represents **Breath Alcohol Concentration**. It follows the outline of the accepted blood to breath ratio in expressing alcohol concentration as grams of alcohol per 210 litres of breath.

In the United Kingdom, the legal limit is defined as 35 microgrammes per 100 millilitres of breath. This is equivalent to 80 milligrams, (0.08 grams) of ethanol per 100 millilitres of blood.

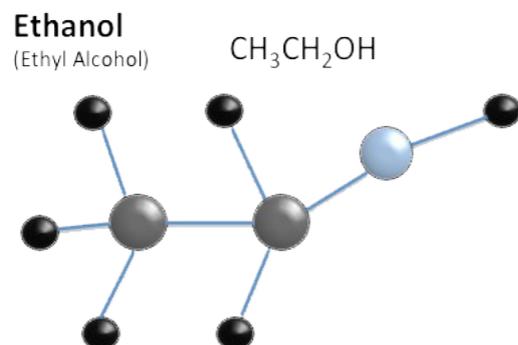
Standard Drink - In North America, “Standard Drinks” deliver the following ethanol:

Beer	12 ounces @ 5% = 0.6 ounces (14 grams) ethanol
Wine	5 ounces @ 12% = 0.6 oz. (14 g) ethanol
Port	3 ounces @ 20% = 0.6 oz. (14 g) ethanol
Whiskeys	1.5 ounces @ 40% = 0.6 oz. (14 g) ethanol

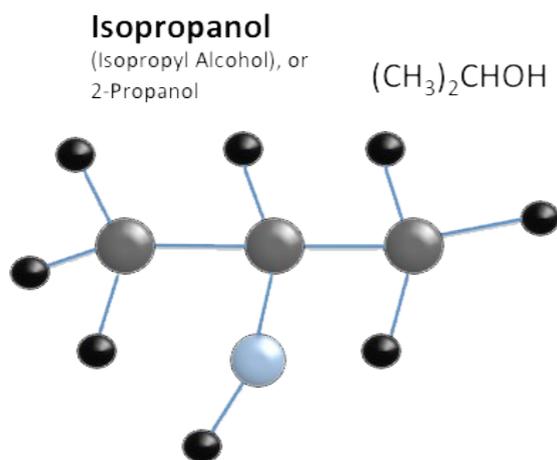
Each standard drink will impart an equivalent level of raw ethanol to the subject, and create an equivalent level of alcohol concentration in the blood, breath or urine of an average male subject of about 20 milligrams/100 mL. Each country or region seems to have its own standard for drink size and alcohol concentration. Not all “Standard Drinks” produce a BAC of 20 milligrams/100 mL.

Glossary of Terms (Continued)

Ethanol – Ethyl Alcohol, or C_2H_5OH . This is the alcohol found in alcoholic beverages. Ethanol contains two hydrocarbon groups in its chain.

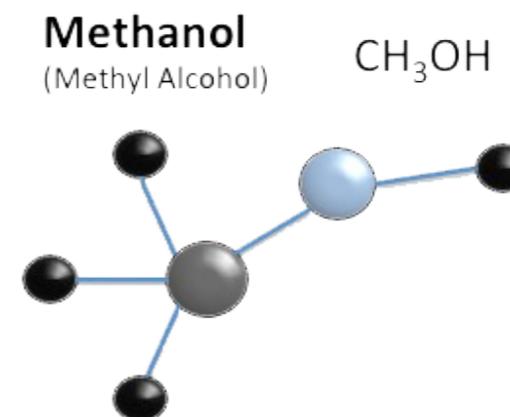


Isopropanol- [isopropyl alcohol, rubbing alcohol, 2-propanol, $(CH_3)_2CHOH$]. Found in rubbing alcohol at about 70% w/v. Also used in many aftershaves and perfumes as a solvent for the aromatic hydrocarbons used to provide scent. $LD_{50} \approx 250$ milligrams/100 mL. Contains three hydrocarbon groups in its chain. Note that isopropanol and propanol are two distinct molecules, even though they have the same number of constituent atoms. It is the *arrangement* of these atoms that accounts for their different chemical properties, and hence, their different names.



LD_{50} – Used by toxicologists to ascribe toxicity levels. LD_{50} refers to the Lethal Dose in 50% of the population subjected to the dose described. It is a theoretical calculation, NOT empirically tested. With respect to ethanol, the LD_{50} is about 400 milligrams/100 mL, or 0.400 grams/100 mL. However, keep in mind that this is just a rough average. Individuals have succumbed to ethanol toxicity at lower levels, and also survived much higher dosages.

Methanol - [methyl alcohol, wood alcohol, CH_3OH]. Methanol, commonly used in industrial processes, some paints, and gas line antifreeze or windshield washer solutions. Methanol is used as “fondue fuel”, and used in some camping stoves. $LD_{50} \approx 75$ milligrams/100 mL. Contains a single hydrocarbon group in its “chain”.



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Understanding Infrared Spectroscopy

In Brief:

It may seem that the numbers generated by a modern breath alcohol analyzer are a little mysterious. *How exactly does a breath-testing device generate a result?* Most modern evidentiary breath alcohol testers use *infrared spectroscopy* to determine the presence and concentration of ethanol in the sample being analyzed. In order to understand how a breath test device captures sample data, you need to understand some of the theory behind infrared spectroscopy. This article will introduce some of the important concepts behind this technology.

The follow-up articles in Parts 2 & 3 will first show how the technology is applied to breath alcohol testers, and then the limitations of that technology.

Introduction

The existence of the infrared spectra has been known since about 1800. We knew it existed, we just didn't know how to apply the knowledge to anything useful, in much the same way that an early understanding of electricity was little more than a parlor trick played with rabbit fur and an amber rod. It is only in the last century or so that the science has become refined and applied to the testing of organic and inorganic molecules. Let's start with a discussion of various forms of energy, so that we can focus specifically on infrared measurement.

Electromagnetic Energy and the EM Spectrum

Electromagnetic (EM) energy exists in many forms. If it doesn't occur naturally, then you need a source to *generate*, or create, the energy. The microwave oven in your kitchen is a generator of Microwave EM radiation. Your cell phone creates Radio EM energy. X-Ray devices create that specific wavelength of EM radiation at the hospital to examine your body, or the airport to search your luggage. Infrared lamps might produce that specific form of EM radiation at the physiotherapist's office to treat your swollen knee. All of these devices create different forms of the electromagnetic energy. We measure and identify those forms of energy using a length of measure called a *wavelength*. The length of the infrared wavelengths is measured in microns, which is abbreviated "μ", or sometimes with the letter "u".

You also need a *detector* to identify and measure the energy present. As an example, your car radio is a detector of EM radio waves. If your musical tastes don't appreciate opera, or rap - too bad. Local radio stations (broadcasting the music you either like or don't like) are generating radio waves that are passing through your body right now. You just don't have a receiver in your head to pick up the constant stream of signals – or in more scientific terms - to detect the continuous and overlapping EM radio energy passing through your body right now. *If you did, you would probably want to wear a little tinfoil hat, not that it would help.*

Obviously, there is considerable energy transfer with most forms of EM energy. In the low end of the invisible spectrum, energy is still transferred, just a lower amount. *Radar* waves have been known to burn out delicate electronic equipment, and there is debate about the apparently higher incidence of testicular cancer amongst police radar operators, who often leave their radar "guns" lying on their laps in standby mode while running radar. *Microwave* energy transfer occurs in many kitchens every day. We call it "cooking".

The infrared portion of the spectra is also an invisible range, just below red in the visible light spectrum. It is named for *infra*, from the Latin for below, and *red*, the color to which it is below. Infrared energy is also measured in wavelengths. We actually generate infrared energy with our own bodies – forming the basic principal of night vision goggles and the passive sensors the TSA uses to screen us at the airport. In fact, half of the energy output of our Sun is infrared radiation, so we are bombarded with it daily. Without it, we would freeze.

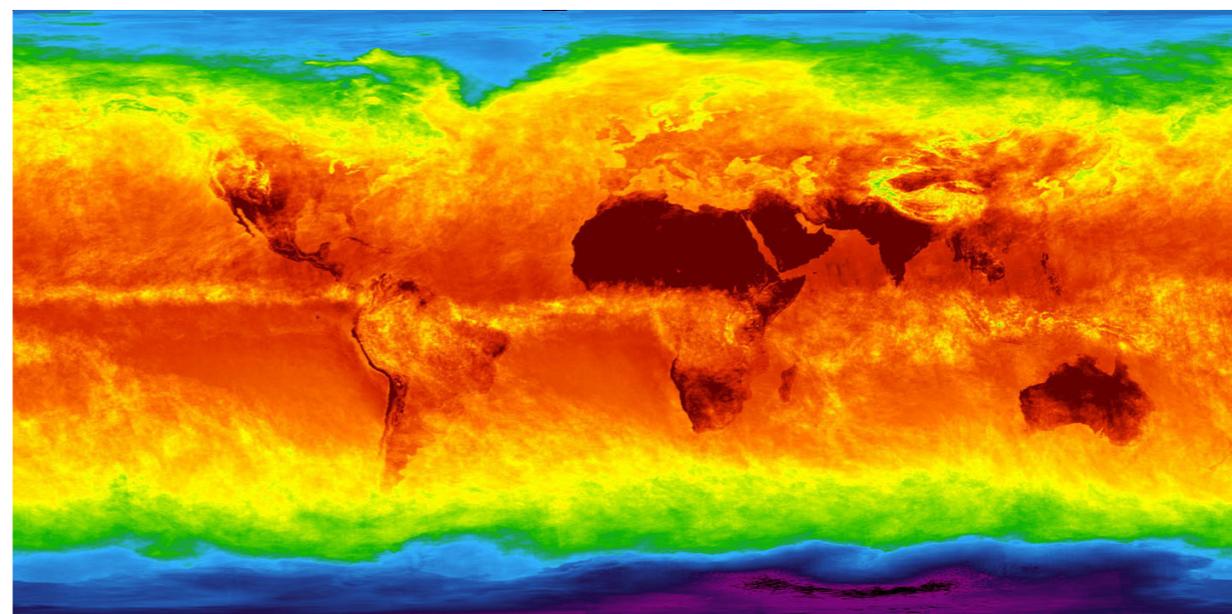


Figure 1 - The Earth as represented by its infrared signature as visible from space. The darkest reds are the hottest regions. Blues and purples represent the coldest regions.

In the *Visible Light* spectrum, energy transfer is still considerable. Most people have experienced sunburn, or the shock of flicking on the bathroom light in the middle of the night. If you've ever been to the beach, or stood on a stage with the theatre lights shining down, you will appreciate the considerable amount of energy transfer of light.

On the other end of the visible light spectrum are the ultraviolet ranges and more (from the Latin *ultra*, meaning beyond, and *violet*, the color to which it is beyond). If you've ever had a filling cured by the dentist using that light probe stuck in your mouth, you've experienced first hand the transfer of *Ultraviolet* energy. The amount of ultraviolet radiation you receive should also be subject to control measures, as the Sun emits UV radiation along with both visible light and IR energy. Wearing sunscreen will reduce your risk of UV exposure that causes skin cancer.

Energy at shorter wavelengths, being even higher in frequency, can do a lot of damage. Most people prefer to limit the number of *X-Rays* they receive annually. At the shortest wavelength, but highest energy output, *Gamma Rays* are quite deadly. Atomic weapons generate this last form of EM energy.

In this diagram we see the various types of energy, and a rough correlation of their wavelengths. It is important to keep in mind that there are no set delineation points between one type of EM energy and the next. Don't get too concerned about the boundaries. Ranges overlap, and some energy levels can be considered to have characteristics of both their neighbors.

As an example, some visibly red light has infrared properties. Infrared lamps keep the food warm at the buffet, but we can still see the red light. Some infrared sources also emit microwaves, and some ultraviolet rays have properties of X-rays. Visible light has both IR and UV components. The artificial divisions we create are for the convenience of humans, who find comfort in compartmentalizing intangible ideas.

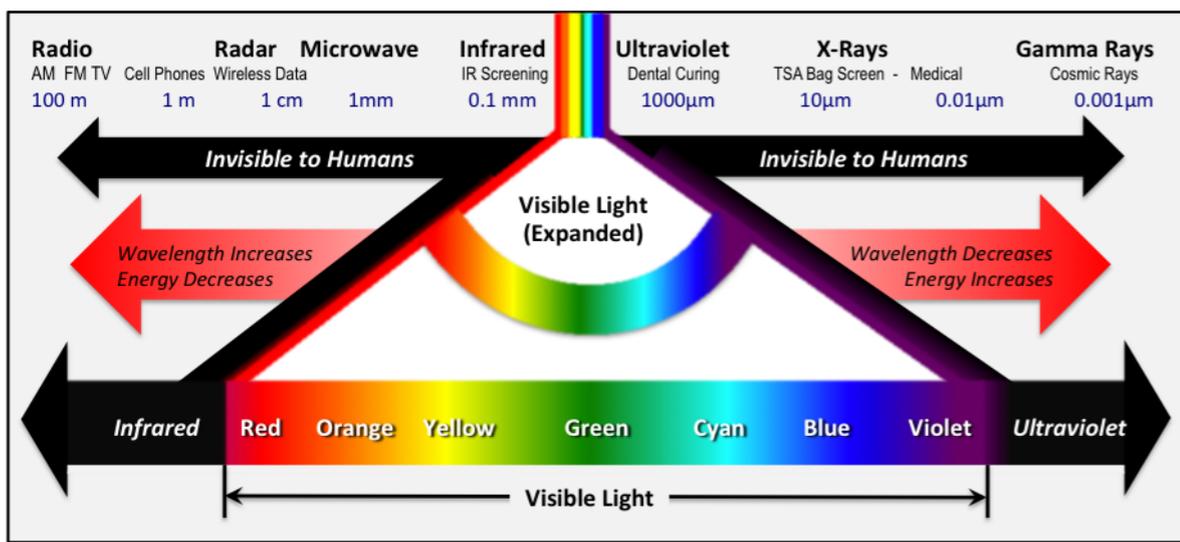


Figure 2 - Diagram of the Electromagnetic Spectrum



Figure 3 - The Intoxilyzer 8000 measures ethanol using IR absorption

OK, so we are dealing with infrared energy in breath alcohol testing. *Why does this matter?* Breath test devices use the characteristic of IR energy absorption to detect ethanol molecules in the breath sample. The molecules will absorb some of the IR energy beamed through the sample. More absorption simply means more molecules of an absorbing substance are present. The devices are designed so that the absorption directly refers to ethanol and hopefully not something else.

Absorption of Energy & Beer's Law

Imagine being at a movie, a much-anticipated sequel. As the movie starts, people start to get up in front of you. Some people go for popcorn; some people go to the bathroom; some change seats. One guy just walks back and forth randomly in front of your seat muttering to himself. Your ability to see what happens to your beloved lead character is being severely compromised by the people passing in front of you.

In scientific terms, their opaque bodies are blocking (or completely absorbing) the EM radiation - the visible light wavelengths in this case - bouncing off the screen, and into your eyes. Your eyes are the EM detectors in this example. As more people walk in front of you, their absorbance of the EM radiation from the screen increases. You see less and less. In other words, your eyes - your EM detectors, receive less transmitted EM radiation. Frustrated, you leave the theatre and wait for the movie to come out on Netflix.

In a sense, infrared breath alcohol testing works in exactly the same way as the movie analogy. The ethanol molecules are absorbing some of the infrared energy *generated* by the breath alcohol-testing device on one side of the test chamber, and *measured* on the other. Some of the transmitted IR energy is absorbed by the ethanol molecules. The breath test device needs, however, to be discriminate towards ethanol molecules placed in front of its detector to get a true reading. For that, we need to delve a little further into physics, and learn something about organic chemistry.

Beer's Law

The movie analogy demonstrates Beer's Law. The Beer-Lambert equation (simply called *Beer's Law*) is the nearly linear relationship between *absorbance* and *concentration* of an absorbing substance. In other words, if we increase the concentration of a substance in a test cylinder, we will increase the amount of radiation *absorbed* by that substance. More people in front of you at the movie means more absorbance of the light.

In the breath test device, an increase in the ethanol concentration inside the test cylinder will increase the amount of EM radiation absorbed by the ethanol, and decrease the amount of EM transmission of IR energy through the sample. Once we can measure the amount of energy being absorbed, we can quantify the amount of substance in the sample.

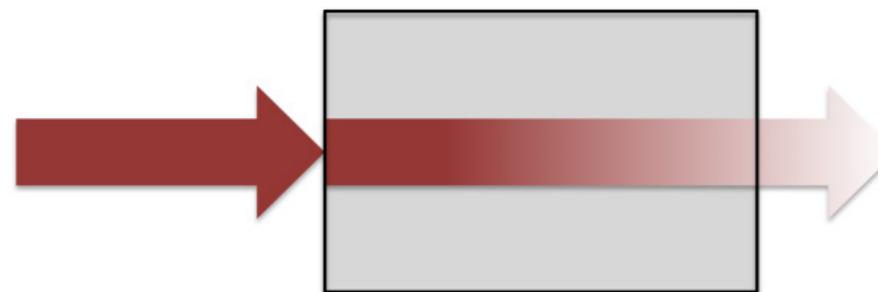


Figure 4 – Beer-Lambert in action. IR energy passing through the sample cube is being absorbed by something in the cube.

It is the *Beer-Lambert Law* (referred to simply as *Beer's Law*) that has a direct implication in the operation of infrared spectroscopy breath alcohol devices. We need to link the concept of electromagnetic radiation and infrared spectrometry to understand Beer's Law.

Specifically – *What are we measuring?*

The EM Spectrum, and Infrared Breath Testing Hydrocarbons, the Alcohols and Organic Chemistry

I'll give you a clue. We are not actually measuring the whole molecule in the test sample. We are only going to measure a *part* of the molecule. Specifically, we are going to measure *two or more of the bonds between the atoms* that form the molecule.

Organic chemistry deals with the bonds of carbon compounds. Alcohols have a chain of hydrogen-carbon bonds, called *methyl groups*, and with a “tail” attached that is an oxygen-hydrogen pairing, called the *hydroxyl group*. Each of these is referred to as a *functional group*¹. By adding more and more methyl groups together in the chain, the alcohol molecule gets longer and more complex.

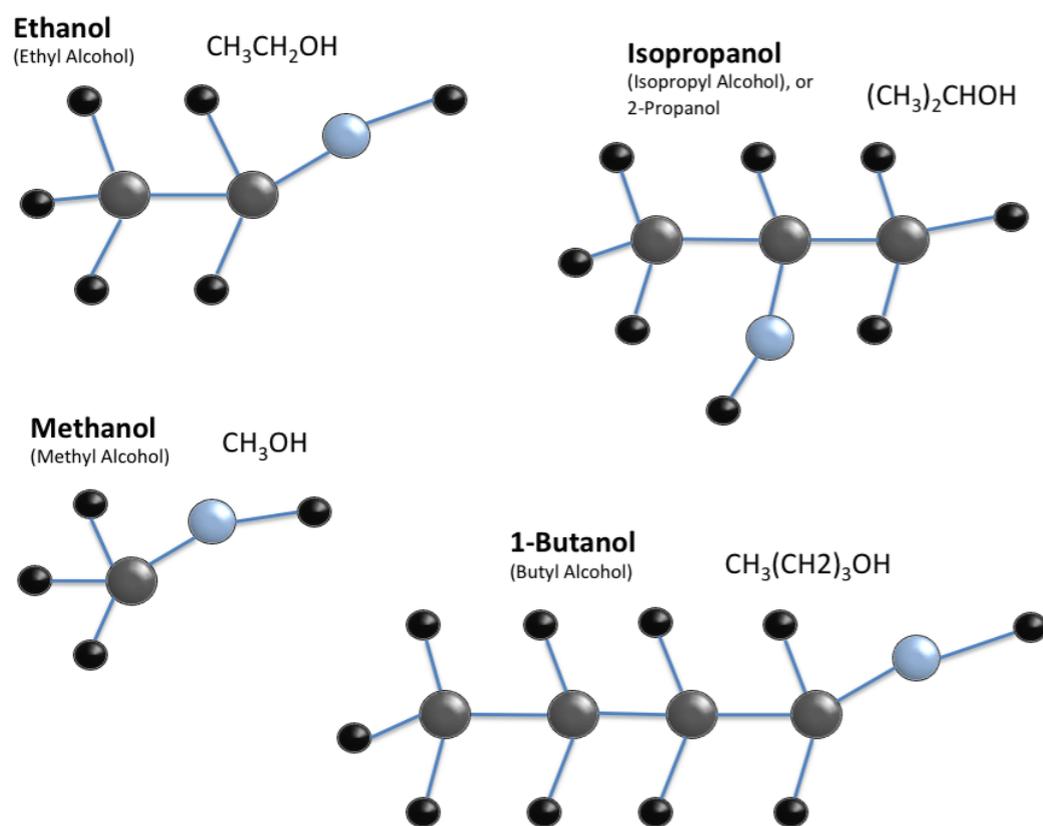


Figure 5 - Diagram of the alcohol family. Carbon molecules are in gray, hydrogen in black, and oxygen in light blue.

¹ A functional group in chemistry refers to a particular pattern of atoms that occurs time and time again in different molecules.

Methanol exists as a “chain” of a single hydrocarbon methyl group, Ethanol has two hydrocarbon methyl groups in the chain, Isopropyl alcohol has three methyl groups and Butyl alcohol has four, as shown in **Figure 5**. Each one of these collections of carbon-carbon chains forms a marriage with the oxygen-hydrogen (or hydroxyl) group, to form *an alcohol*. *The presence of the hydroxyl group makes the molecule an alcohol*. Because the alcohol molecules are similar in form, they behave similarly in function.

For about 150 years, we've used the “*Ball & Stick Model*” to represent molecules, although this is really a grotesque oversimplification. But, the model does show the relative assembly of individual atoms in the molecule to make the grouping. The “sticks” keeping those molecules bound together are continuously vibrating, even if the compound is in a solid or liquid state. It is helpful to think of the bonds in the molecule as flexible springs, and not as straight sticks. The bonds between two atoms in a molecule will vibrate perpetually at their own rate, or *frequency*. The bonds between hydrogen and oxygen atoms vibrate at a different frequency than between a pairing of hydrogen and carbon molecules. The bond energy is measurable, in the form of a *frequency rate*.

Infrared Spectroscopy

So, each molecule is a flexible, moving collections of atoms. The atoms in a molecule are constantly oscillating around average positions. Bond lengths and bond angles are continuously changing due to this vibration. A molecule absorbs infrared radiation when the vibration of the atoms in the molecule produces a vibrating electrical field with the *same* frequency as the frequency of the IR energy striking the molecule. *In other words, when the frequencies match, there is complete absorption. If the frequencies are totally opposite, the wavelength of energy will pass through totally unabsorbed.*

Due to this frequency in the vibration rate of the bond pairs, EM radiation attempting to pass through the molecule will be absorbed or transmitted through the molecule at different wavelengths. If we subject the molecule to a continuous range of frequencies, some of the frequencies will be absorbed by a matching frequency in the bond vibration of the atoms, and some frequencies will pass through unabsorbed because there is no matching frequency in bond vibration. Remember, at the wavelengths we are using, the EM signature is in the “infrared” region, just below the visible light range of red light.

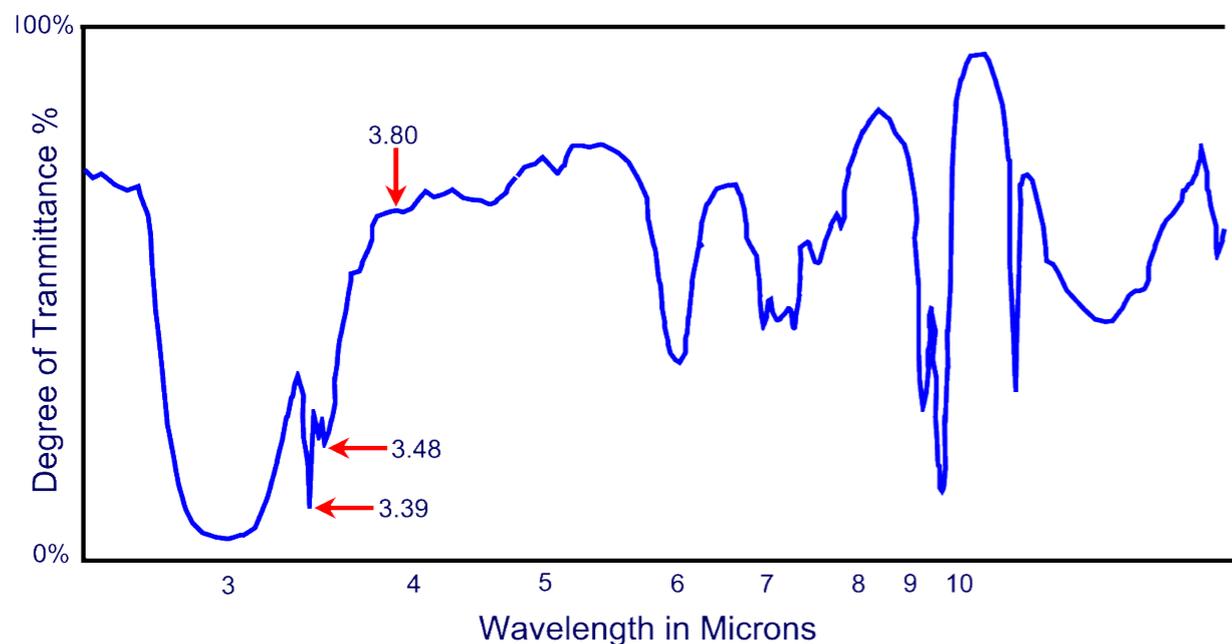


Figure 6 - EM Spectrum for Ethanol

The absorbing wavelengths will therefore always be the same for identical types of bonds. A detector for the wavelengths placed behind the molecules will show an absorbance of that EM signature by the molecules, much the same way as your eyes detected the absorbance of the movie EM energy being absorbed by the annoying patrons in our theatre example. The difference in actual measurement, though, is that in the analogy, the EM radiation is actually being absorbed by the people, while in infrared spectrometry, the EM radiation is being absorbed by the energy binding the molecules together.

As you know, all chemical compounds are constructed using a series of molecules, assembled together in unique patterns for each compound. The bond patterns between the various molecules are unique, because the compounds themselves contain unique patterns. If an infrared EM source is “beamed” through the molecules, a unique energy absorption pattern will emerge, with peaks and valleys representing the absorption or transmission of energy through the chemical bonds.

The alcohols have similar physical forms, and therefore similar infrared characteristics. However, the energy absorption for methanol will be different than that of ethanol, and ethanol different from isopropanol. So, each chemical compound has a unique pattern of absorption. This signature, or “fingerprint” as it is sometimes referred, is identifiable to a particular compound. In fact, each part of the fingerprint is characteristic of the corresponding part of the functional group that is absorbing the EM energy.

Ethanol may have a fingerprint that is *similar* to isopropanol, but it will be *unique as ethanol*. Even *propyl alcohol* and *isopropyl alcohol* have different fingerprints, even though they have the exact same number and types of constituent atoms making up their respective molecules. The different *arrangement* of these molecules makes their IR data fingerprint different and therefore measurably unique.

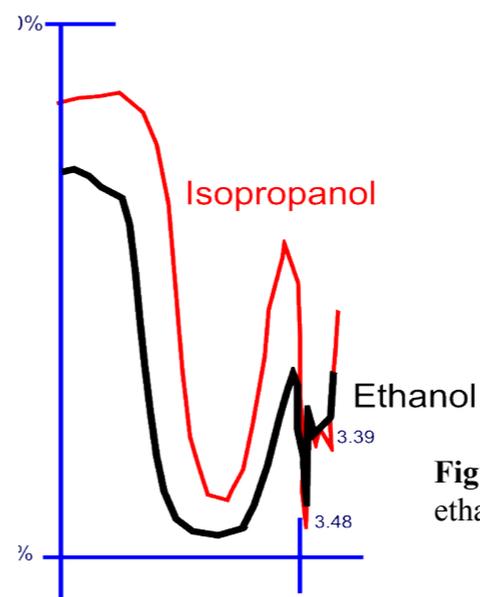


Figure 7 - Comparison of the IR spectra of ethanol and isopropanol at the 3-micron range.

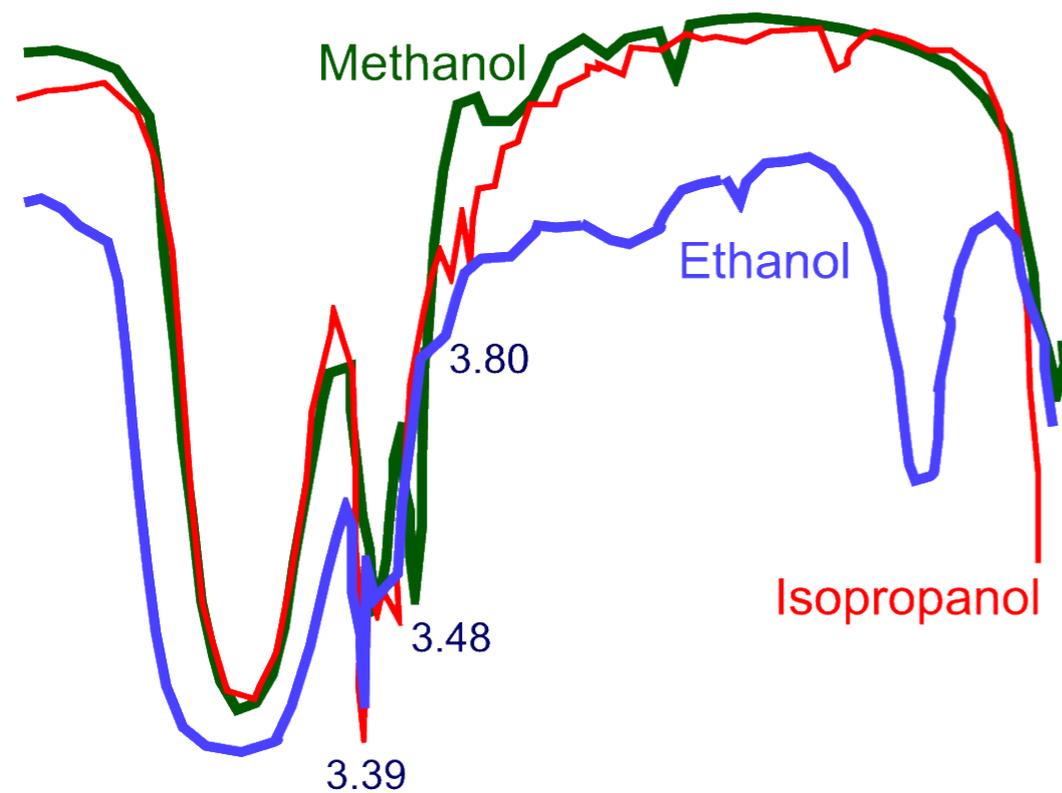


Figure 8 – Spectra of the alcohols with their similar patterns

Now we have a choice. We could analyze the entire graph formed by the transmission and absorption of the energy to determine the chemical compound present. In this way chemists or physicists are able to determine the absorbing wavelength of different chemical compounds. When IR breath-testing devices first were released, it was expensive and impractical to do so. Instead, the designers focused on individual points on the graph, and said, “If they are present, then the molecules that produce that unique fingerprint must also be present.”

Let’s use a simpler breath-testing device as an example – an early series Intoxilyzer 5000. Look at the diagram of the infrared absorption of ethanol below². We have a very strong EM absorbance at the frequency rate of 3.39μ (microns), a smaller but still measurable absorbance at 3.48μ , and a minor but measurable absorption at 3.80μ . We can therefore use 3.80μ as a *reference point*. It has become our imaginary zero point, for convenience’s sake.

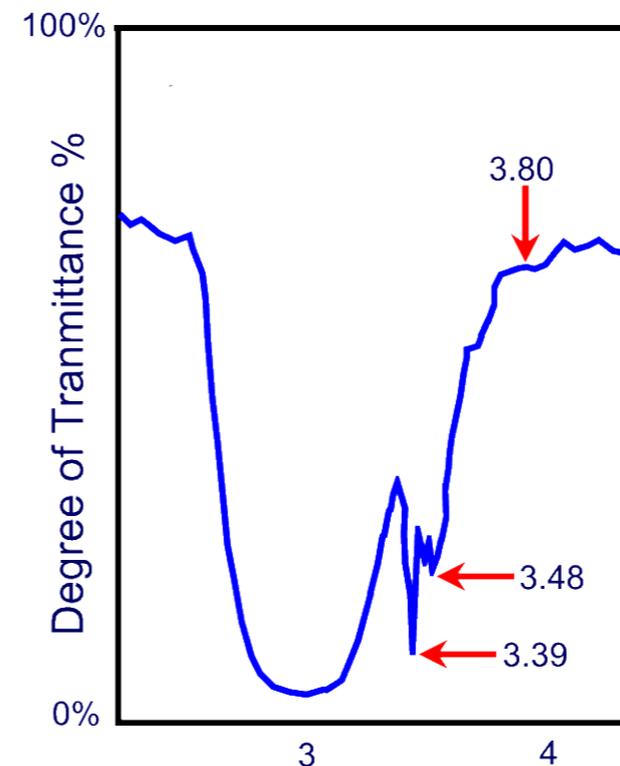


Figure 9 – Three points of interest on ethanol’s IR Spectra as read by the Intoxilyzer 5000, shown on the right. This unit was first introduced in the late 1980s, and is still in use in many jurisdictions today, although it is slowly being phased out and replaced by newer units, like the Intoxilyzer 8000 (introduced in 2000), and the latest model - the 9000.

It follows that if in the test chamber, there is a strong absorption of infrared radiation at 3.39μ , there *may* be a strong presence of ethanol. *But, is it possible that there could be absorption at 3.39μ with a substance other than ethanol?*

² These diagrams are *representative* in nature, and are not intended to be *absolutely accurate* depictions of the EM signatures of the molecules.

There could be, and in fact there are many other substances that can absorb strongly at precisely 3.39μ . Isopropanol and methanol also absorb strongly here, but that fact is really not important now, because the chemists use another feature to determine the presence of any specific compound. Look again at the diagram of ethanol below, paying attention to the absorbance at 3.80μ .

Notice that there is some, but little absorption at this wavelength. We can measure, then, the difference in the absorption between 3.80μ , which we artificially set as “zero”, and 3.39μ where ethanol is strongly absorbed. We can call that difference “X”. We also notice a strong rate of absorption at 3.48μ . The difference, “Y”, between the readings at the two wavelengths of 3.80μ and 3.48μ also indicates the amount of ethanol in the test cylinder. This scientific principle is known as bichromatic photometry. Two “colors” (or wavelengths) are used as a measurable comparison.

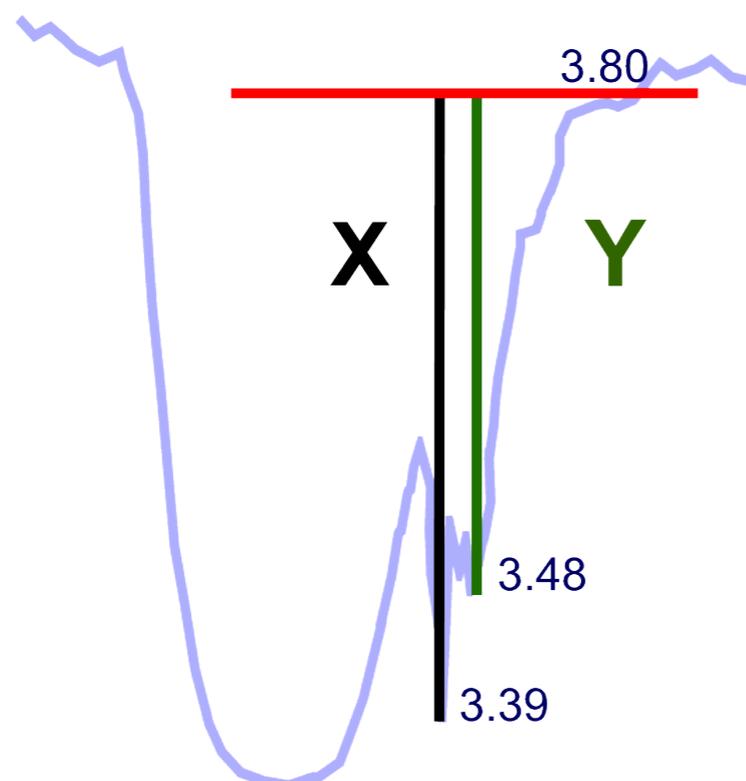


Figure 10 – Ethanol’s IR spectra with X&Y lines, showing the 3.80μ point used as an artificial baseline (in red).

If line **X** is present, there must be a strong absorption at 3.39μ . That is all we can really say with certainty. If line **Y** is present, there must be a strong absorption at 3.48μ . Again, that is all we can say with certainty.

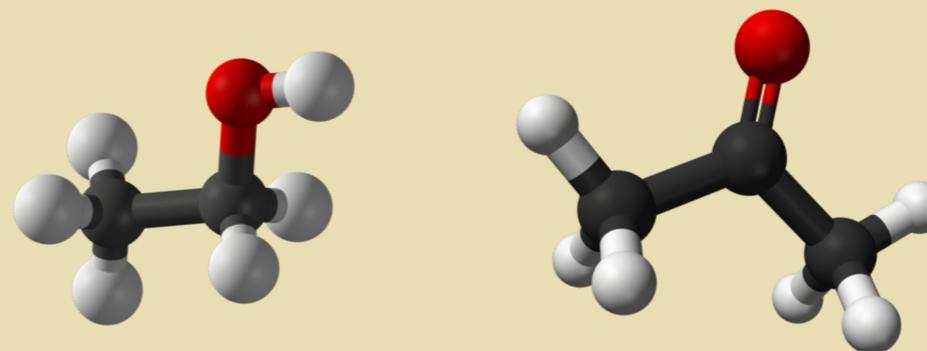
However, in all *ethanol* molecules, the ratio between line **X** and line **Y** is *known and predictable*. It will always occur in this ratio. It is not affected by any external influence. It becomes an identifier.

Therefore, if there is absorption producing lines **X** and **Y** that are in the *exact ratio as are known to be produced with ethanol*, we therefore *assume ethanol must be present*.

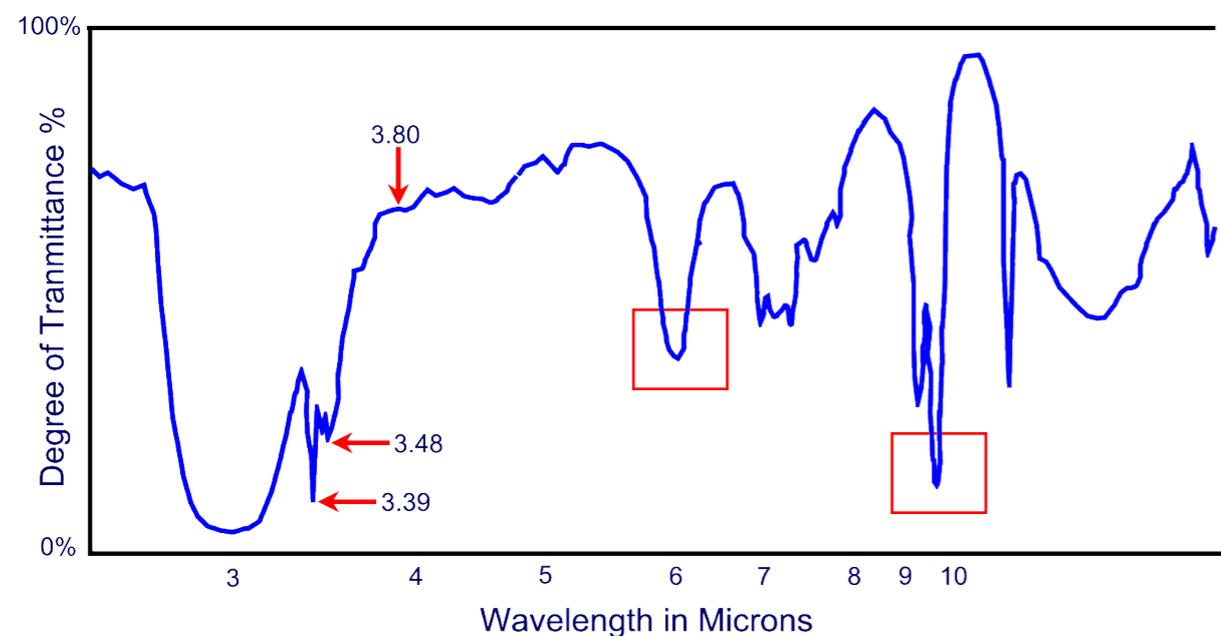
From Beer’s Law, strong absorption of the IR energy passed through the sample chamber, *as long as it is at this consistent X-Y ratio*, means that there is a greater amount of ethanol in the test chamber.

This is more than an intellectual exercise in understanding IR analysis. Human beings have more than just ethanol on their breath naturally. In fact, there are hundreds of naturally occurring (or *endogenous*) volatile substances that may be found on your breath. Some are dependent upon your medical background. Others may be present due to occupational exposure to different hydrocarbon chemicals at work.

Understanding how the evidentiary breath test device is measuring ethanol is important when we consider these other chemical compounds. This issue is known as *Specificity*, and it is critical in breath alcohol testing. It will be the subject of many future articles.



An infrared breath alcohol device could use a series of filters to determine the absorption at each wavelength where ethanol is known to absorb energy. The entire “fingerprint” could be read. Going back to our original representation of this absorption, you see a strong absorption peak at 3.39μ , a smaller absorption at around 6μ , and a large absorption spike between $9-10\mu$, as indicated in the red boxes:



The newer Intoxilyzer Models 8000 and 9000 use absorption in this $9-10\mu$ range. So also do the Dräger 7110 and 9510 models. We could conceivably construct an instrument with IR filters at a number of known absorption or transmission peaks to get a reading that was extremely specific for ethanol. More data points do perhaps make the reading obtained more desirable, as it is easier to establish specificity for ethanol. But, more data points require a greater complexity in the algorithm that does the calculations, more RAM, more filters, and more that can go wrong. In the past, these components were expensive, and required more programming and computing power to make the instruments work. Bichromatic measurement does work, albeit with limitations, as we will see in future articles.

Conclusion

So, we have two separate and distinct schema woven into one technology. First, the Beer-Lambert law allows us to measure the *quantity* of a substance in the test chamber by measuring how much radiation, overall, is being absorbed. More absorption of energy passing through the test chamber simply means a greater concentration of the absorbing substance in the chamber. That is how breath test devices determine how *much of something* is in the test chamber. It is a *quantitative* measurement.

Secondly, by measuring the absorption or transmission of specific wavelengths of energy passing through the molecule, the units are able to determine the *identity* of the absorbing substance. This is a *qualitative* measurement. Ethanol absorbs IR radiation differently than isopropanol or methanol at specific wavelengths. By determining the specific absorption pattern, and comparing it against a known and measured response, the units are theoretically able to distinguish between different molecules. *Future articles will examine issues in the specificity of various breath test devices.*

This technology is not just applied to breath testing. Any volatile compound can be analyzed using this method. Astronomers use this method to determine the wavelength of infrared particles emanating from distant stars, and to determine the composition of the atmospheres of our neighboring planets. *In the next article in this series, we will look at the use of infrared spectroscopy as it is applied to breath testing, and delve a little deeper into the intricacies of this technology.*



More to Explore:

Semenoff, J., *Intoxilyzer Breath Alcohol Testing - Professional Edition*, Industrial Training & Design Ltd., Saskatoon, 2004.

Glossary of Terms

Beer's Law - The Beer-Lambert law. The Beer-Lambert law relates to the absorption (or *attenuation*) of light as it travels through a material. The law is commonly used in chemical analysis measurements. Lambert used a previous researcher's 1729 article to formulate his first law in 1760. By 1852, Beer was basing his research on the previous two works. The modern derivation of the law combines all previous works.

Bichromatic photometry – The process of using a comparison between two known readings to establish a ratio. Used in most modern infrared breath alcohol analyzers. May also be used as a comparison between colors, as in the original Borkenstein Breathalyzer.

Electromagnetic Radiation - Radiation consisting of waves of energy associated with electric and magnetic fields resulting from the acceleration of an electric charge. May be naturally occurring in nature, as light, heat or radiation, or artificially produced by electrical fields, emitters and sources of power or energy.

Infrared Spectroscopy – A means of measuring the type and quantity of molecules using the energy absorbing characteristics of infrared energy, and its interaction with the electromagnetic bonds holding molecules together.

Interferent – A substance that has chemical or physical characteristics that makes it virtually indistinguishable from the substance being tested. 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. 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. *See Specificity.*

Micron – One millionth of a metre; $\frac{1}{1,000,000}$ metre; 1×10^{-6} metres. The micron is commonly expressed with the unit “ μ ”. May be expressed using the letter “u”. IR wavelength measurements are made in microns.

Specificity – The quality of referring to a *specific*, or particular substance. 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.*

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An Introduction to DUI Investigations

In Brief:

The DUI investigation is unique. They are ubiquitous events requiring much skill and knowledge on the part of the legal professional. In order to effectively manage these cases, you need to invest the time to master a great deal of often-complex scientific and technical information. We will examine some aspects of DUI arrest statistics. We will also focus on the relevant components of a DUI investigation you need to master.

What are we dealing with?

The FBI has recently released their *Uniform Crime Reporting* (UCR) Statistics for the last complete year – 2013. In the United States that year, DUI arrests accounted for about 10% of ALL persons arrested. In total, more than 11 million people were arrested for all tracked criminal occurrences combined. More than 10% (1.16 Million) of those arrests were for DUI offenses. That equals about 3200 DUI arrests per day in the United States – or on average, 133 DUI arrests per hour. *More than two per minute...*

How does the US compare with other industrialized nations? With a total population in 2013 of about 316 million people, that gives a DUI arrest rate of 374 per 100,000 people. In comparison, Canada had a DUI arrest rate of 242 per 100,000, France a rate of 227 (in 2005, the last year reported), and the UK a rate of 103.

See Table 1 for a breakdown of the numbers.

	USA 2013	Canada 2012	France 2005	UK 2011
Population	316,000,000	34,750,000	63,180,000	58,300,000
Total Arrests	11,302,000	N/A	N/A	N/A
DUI Arrests	1,167,000	84,500	150,000	60,000
% Pop	0.37%	0.24%	.23%	.10%
% All Arrests	10.3%	N/A	N/A	N/A
Rate per 100K	374	242	227	103

Table 1 - International comparison DUI arrests, per capita

Of course, DUI arrest statistics are tricky things. It is easy to look at these numbers, all of which are estimates based on reported trends, and draw false conclusions. All the nations compared have a legal limit equivalent to .08 grams, with the exception of France, who just recently lowered their legal limit to .05 grams in response to one of the highest DUI fatality rates in Europe. In the US, both Maine¹ and Colorado² have enacted legislation that sets one of the DUI threshold limits at .05 grams. Maybe we are comparing apples to oranges in regards to legal limits.

We also can't compare the relative definitions of two other offenses included in these numbers – “impaired driving”, and “refusing a chemical test”. What constitutes “impairment” in one area may be different in another, and is highly subjective in any event. In some jurisdictions, you must be in physical operation of a motor vehicle to be charged, while in others, mere “care and control” is enough. Some jurisdictions may have lower apparent DUI statistics because refusing a breath test is a legal option for the person detained. In other jurisdictions, “refusal” charges are dealt with along the same lines as a criminal DUI component and are therefore included in the DUI statistics. Comparing DUI rates among jurisdictions and drawing meaningful conclusions is virtually impossible.

The other tricky thing about DUI arrest stats has to do with enforcement options made by the officer at roadside. Often, arrest decisions are made with regard to external factors. For instance, some police agencies focus on DUI arrests with a greater degree of enforcement than others. Policy decisions play a role in allotting police resources, officers and equipment. Breath test devices are expensive, and the training of officers to use those devices or perform specific investigative tasks related to DUI investigations equally expensive. It is costly to assign officers and provide administrative and support resources to enforcement duties in any one specific task, regardless of the desire to establish a DUI task force.

1 § 2432. ALCOHOL LEVEL - 2. Level greater than 0.05 grams and less than 0.08 grams.

2 DWAI (Driving While Ability Impaired), triggered by .05% BAC or higher (but less than .08% BAC).

Individual officer's perceptions also play a role. Some front line officers arrest many DUI suspects over the course of their careers, while other patrol or traffic officers arrest very few. I've heard officers comment that they try not to arrest DUI suspects because they have to sit with them for an hour or more processing the arrest and conducting the tests, and prefer not to have this direct personal contact.

On some nights, arresting a DUI offender may be less likely to occur as officers are too busy responding to calls for assistance for violent offenses, or offenses in progress that are given higher priority. Policing, like many emergency services, is highly reactive in nature. With limited financial and human resources, the police can only be in so many places at one time, deal with only so many occurrences at once, and as such, incident response sometimes has to be re-prioritized.

Enforcement options may explain why the DUI arrest rate in North Dakota is 873 per 100,000 people, while Alabama had the lowest reported arrest rate at only 5 per 100,000 people. Maryland, in comparison, sits at USA's national average rate of 374. It is difficult to imagine that the *true* rate of impaired drivers is 174 times higher in North Dakota than Alabama. *Resist the temptation to make any bad jokes here...*

I spoke with two lawyers from North Dakota, and two from Alabama in what is certainly too small a sampling populace to be an accurate analysis of the situation. However, all agreed that the statistics were reflective of arrest decision realities and fiscally driven enforcement policies rather than a representation of the true picture of DUI s in their respective states.

In North Dakota, it was felt that the by-in-large rural officers had less pressing matters presented to them in their daily patrol routines. The investigation of DUI incidents became a focus, given that the offenders would leave the local tavern or restaurant and drive a long distance through rural areas to reach home, often in potentially

dangerous inclement weather. However, it should also be noted that North Dakota had the highest rate of DUI fatalities in the United States, with a rate of 8.6 fatalities per 100,000, compared to 3.2 for a national average. Maybe their vigilance in DUI arrests is warranted. This, of course, opens the debate as to whether or not high DUI enforcement activity combats DUI fatality rates.

Also, the police to population ratio in Grand Forks, and Fargo are about 145 officers per 100,000 residents. In comparison, the national average for the police to population ratio is 201 officers per 100,000 residents. This includes all sworn officers, both field personnel and front-line leaders, but does not include clerical or other non-police administrative support staff.

Alabama presented a much different picture. With fewer infrastructure dollars to fund police agencies, Alabama has seen a decline in the police-to-populace ratio over the last number of years. With the greater metropolitan areas taken into account, Birmingham has only 37 officers per 100,000. Mobile is in an even more precarious situation, with only 20 sworn officers per 100,000 residents.



The different staffing levels certainly sheds light on the apparent discrepancy in DUI arrest numbers between Alabama and North Dakota. When we take into account the differences in the FBI's reported *Violent Crime Rates*³ between the two regions, the dissimilarity is even more apparent. On average, North Dakota had only 245 violent crimes per 100,000 while in comparison Alabama had almost twice that rate at 450 violent incidents per 100,000 people.

Chart 1 compares Alabama and North Dakota to one another and the national average among 4 indices: DUI arrest rates, officers per capita, violent crime rates, and DUI fatality rates, all per 100,000 people

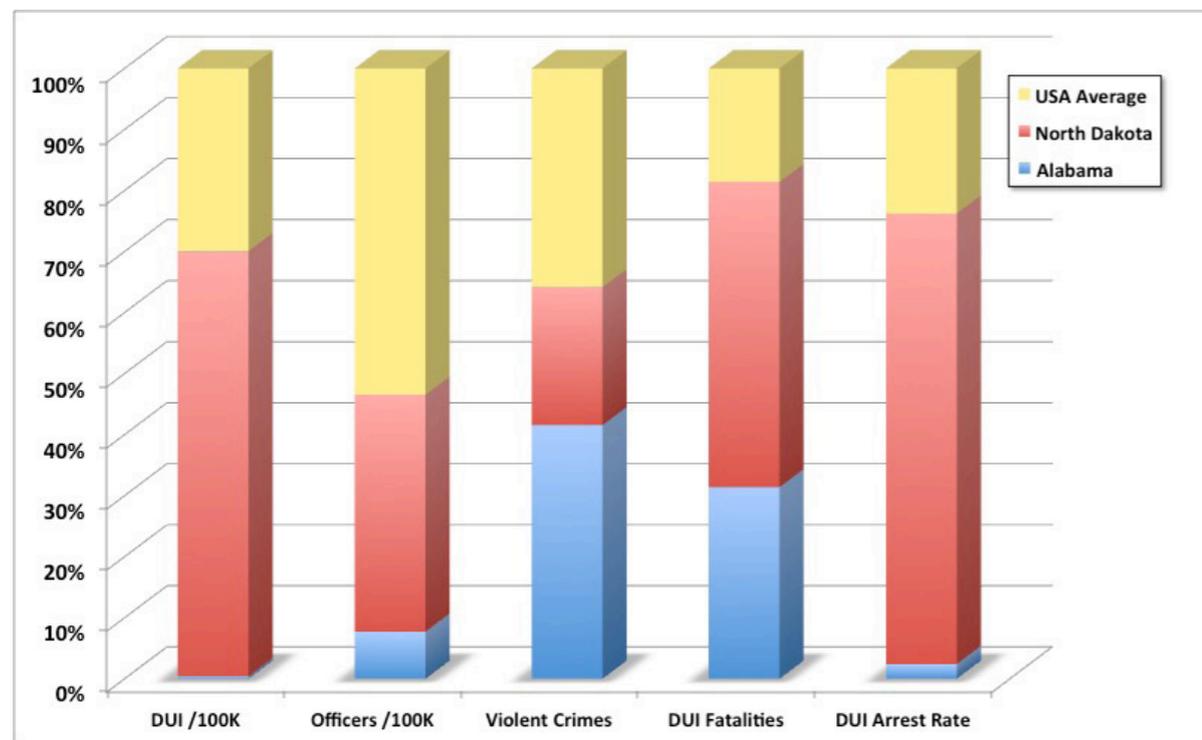


Chart 1 – DUI statistics, USA 2103. The raw data is included below:

	DUI /100K	Officers /100K	Violent Crimes	DUI Fatalities	DUI Arrest Rate per Officer
Alabama	5	29	450	5.4	.19
North Dakota	873	146	245	8.6	5.9
USA Average	375	201	388	3.2	1.9

³ In the FBI's *Uniform Crime Reporting* (UCR) Program, violent crime is composed of four offenses: murder and non-negligent manslaughter, rape, robbery, and aggravated assault. Violent crimes are defined in the UCR Program as those offenses which involve force or threat of force

Let's analyze the data, column by column. The first column, DUI arrests per 100,000 people, shows that North Dakota in red has more than 2½ times the national average in yellow. At that scale, Alabama's DUI arrests in blue are not even visible. The next column compares the respective number of officers that each state has, per capita, with North Dakota lower, and Alabama remarkably lower than the national average. They don't have enough police officers in Alabama.

In the third column, we look at violent crimes. You can see that Alabama has almost twice the rate of murder, manslaughter, rape, robbery, and aggravated assault in comparison to North Dakota. They are also higher in this category than the national average, while North Dakota is lower. As a result, additional pressures are put on the police to respond to violent crimes in Alabama, perhaps leaving less time available for DUI enforcement action... Keep this in mind when we deal with the fifth column - arrests per officer.

The fourth column analyses the DUI fatality rate. Alabama's rate is roughly twice the national average. North Dakota, on the other hand, has a DUI fatality rate almost three times the national average.

The final column is interesting. It compares the numbers of DUI arrests per capita, per officer. So, with Alabama having only roughly 14% of the police officers per capita than the national average, but with 1.6 times the rate of violent crime, it is no wonder that the DUI arrest rates are lower. Officers there make about 1/10th the DUI arrest rates in comparison to a national average, taking into account their lower number of available officers.

Alabama doesn't have the necessary officers available to make the arrests, the time to conduct the breath alcohol tests and the resources to process and administrate DUI investigations, especially considering their higher violent crime rate. The statistics are policy and fiscally driven - not truly reflective of incidents of impaired driving.

The DUI Investigation

One further point of interest in our statistical musing is that, in 2013, the rate for DUI s was roughly equal to that of ALL violent crimes reported. In essence, this implies that legal system must contend with the social and financial costs of DUI investigations and arrests with the same demand on resources as all violent crimes *combined*.

Finally, it should be mentioned, that the overall rates of DUI occurrences in North America has been going down for the last 20 years. However, those rates of decrease seem to have stabilized in the last 5-7 years. So too has the violent crime rate. The rates of violent crimes and DUI s are going down proportionately with one another. However, regardless of the statistical breakdown, with roughly 10% of the total arrests made in the United States being made for DUI alone, it is safe to say that these are really very common occurrences.

Overview of a DUI investigation

At the outset, I wish to make clear the following point: Far more technical in nature in terms of investigational complexity, a DUI arrest can present the officer with a number of key challenges, regardless of how commonplace they are. Utilizing standardized coordination tests, chemical tests, or blood analysis requires an understanding of the scientific and technical nature of the evidence being obtained. Procedures have to be followed according to policy for the validity of the testing process to be maintained.

Technical elements must be followed to the satisfaction of a reviewing forensic criminalist who may required to attend court, as in California for example. A small deviation in the process, whether an inappropriately short wait period prior to the taking of breath samples, an unnoticed burp or belch, or even having gum or chewing tobacco in the mouth, can have a detrimental effect on the accuracy and reliability of the breath test results obtained.

The Vehicle Stop

First, the officer must obtain driving evidence that supports the reasonable articulable suspicion to stop a suspect vehicle. We should acknowledge that stopping a vehicle is one of the highest-risk procedures that an officer can undertake, particularly when they operate alone, as do most of the DUI task force officers. Officers are taught to observe for signs of impaired driving through clues such as operating the vehicle too fast, too slow, or weaving within and outside of their lane. The inappropriate use of traffic signals is often observed, along with erratic operation of the motor vehicle. In short, the officer must observe something out of the ordinary.



After gathering driving evidence, and safely stopping the suspect vehicle, the officer typically then approaches the driver and begins their investigation. It is common to ask routine questions regarding production of the driver's license, registration, and proof of insurance. This is typically done to ascertain the driver's response to key questions, their ability to understand questions and respond by producing the appropriate documents, and their physical dexterity in producing these documents.

The Personal Contact

At this point, the officer should be examining the driver for indicia, or signs and symptoms, of impairment. It has been held in many jurisdictions that an odor of alcohol alone is typically not sufficient grounds to continue on with the DUI investigation. As such, drivers are often asked to exit their vehicles for further investigation. The officers might note the manner in which the driver exits the vehicle, and whether they use the vehicle or surrounding environment for support. The officer might note if the driver displays any marked unsteadiness while on their feet.

Standardized Field Sobriety Tests

Once at roadside, batteries of Standardized Field Sobriety Tests (SFSTs) are often conducted. Most of these tests are conducted under the training guidelines of the National Highway Traffic Safety Administration (NHTSA). Officers will often receive advanced training on the implementation and administration of a standardized battery of tests that are designed to assist the officer in determining whether indicia of impairment are present. The tests, *which must be administered in a specific fashion in order to have any validity with their results*, are a further means for the officer to articulate the observable signs and symptoms of impairment in their investigation. *Take a look at the article on the SFSTs in this issue for an overview of the “Fields.”*



The Preliminary Breath Test

Typically, and often regardless of the outcome of the Standardized Field Sobriety Tests, an officer will conclude the contact phase of the investigation by making a request for a roadside screening test. This hand held screening device test is conducted with a portable roadside breath alcohol analyzer. The nature of this device is such that it gives convenient and rapid results, and can assist the officer in determining whether alcohol is a key component of his investigation. In most jurisdictions, the results of the preliminary test are not considered evidentiary in nature. Any numerical value obtained merely confirms the *presence* of alcohol on board the test subject, and is not intended to analytically report an absolute concentration. *Again, take a look at the article introducing Roadside Testing Devices in this issue.*



Under most circumstances at this point, the officer has some decisions to make. If they feel that the driver has consumed alcohol in an amount that would make them unsafe to drive a motor vehicle, or make their driver's license otherwise liable to suspension, they can act. If the officer believes that the amount of alcohol consumed has not rendered the driver incapable of safely operating the motor vehicle, they may be released. In many circumstances, this is a highly subjective decision. Particularly in cases where there is a borderline impairment of mental, physical, or psychological faculties, coupled with a low Preliminary Alcohol Screening (PAS) test result, the arrest decision can be difficult.

Since the PAS results are non-evidentiary in nature, the officer will then attempt to obtain a breath sample result that provides proof beyond a reasonable doubt of both the presence and concentration of alcohol in the blood of the driver. For this reason, another breath alcohol demand is made upon the driver, and they are offered an evidentiary breath alcohol test.



Figure 1 – A Preliminary Alcohol Screening Device - The Intoximeter VXL

Evidentiary Breath Tests

In the vast majority of jurisdictions in Canada and the United States, this evidentiary breath test mandates detention of the test subject, and transport to a police facility where the evidentiary device is located. In some jurisdictions, such as San Diego, a portable version of an evidentiary device is available to Traffic DUI Officers in the trunk of specially designated patrol vehicles. San Diego uses such patrol cars with the Intoxilyzer 8000.

At this point, units like the Intoxilyzer 8000 are prepared to receive suitable breath samples. Modern evidentiary instruments are commonly computerized, relatively self-sufficient instruments, capable of collecting a sample of deep lung air, analyzing it for the presence of ethyl alcohol, and displaying the results in both digital and printed format.

Additionally, most evidentiary units utilize an algorithm that assists the devices in obtaining reasonably accurate and reliable samples. While not 100% foolproof, the devices do have a greater degree of accuracy, precision, and reliability in comparison to PAS hand held devices. *More on these units in Part 2...*

Calibration checks versus calibration

Most evidentiary units employ either a wet-bath or a dry gas cylinder attached to the breath device that is used to deliver a calibration gas standard to the breath alcohol device. This delivers a sample of wet or dry gas laden with ethanol of a known concentration, in order to run a *calibration check* on the device.

It is important to note that this calibration check is simply that – a *check*. No actual *calibration* of the device is performed. As such, if the instrument is operating within its normal functioning tolerance, the calibration check test merely determines that the reading of the alcohol standard reading delivered is achieved, or within acceptable parameters, to the alcohol standard expected. *Perhaps it is close enough...*

If the device is functioning slightly higher or conversely slightly lower than the expected reading, *but still falls within the expected parameters*, there will be no actual calibration of the reading. By *calibration*, one should consider the verb “*correction*”. No correction or re-alignment of the actual reading is performed. There is no attempt to obtain a true value. We measure the unit and know it to be too high or too low, but it is within tolerance.

Calibrations are performed, as required, typically during routine maintenance cycles. Then, if the unit is outside the acceptable range, its value is corrected back to where it should be reading.

This issue becomes particularly important in cases where the reported reading is at or near a legal limit. If the unit is reading higher than expected, and the test subject provides a sample just slightly overs a legal limit, the *true* BAC reading may in fact be *under* a legal limit. This holds true whether that reading is at or near a suspension limit, the *per se* legal limit, or a higher amount where enhanced penalties come into play.

Close enough only counts in horse shoes and hand grenades.

Once the evidentiary breath alcohol results are obtained, the driver can be released under citation, into the custody of a sober person, or transported to a detention facility and given an opportunity to sober up. It is important to note that in many jurisdictions, a traffic stop constitutes a detention under the law. Excessive time taken at the vehicle stop may indeed constitute an unlawful detention. Therefore, officers are expected to process citizens and release them on their way as soon as reasonably practicable.

Again, it is important to identify the highly technical nature of a DUI investigation. Each component in this investigative process has specific technical requirements, all fraught with legal underpinnings, legislative requirements, and supporting case law. As such, DUI investigations, particularly those carried out by traffic DUI specialist officers, are typically carried out in a routine fashion and often with some sort of checklist to ensure that no item is overlooked, or otherwise forgotten. Additionally, experienced officers conduct themselves in such a manner as to minimize mistakes in the DUI investigative process.

A microcosm of the criminal justice system

In order to deal with these files, it is important that the lawyer have more than just a perfunctory understanding of the legal, technological, and scientific issues surrounding the investigation. This goes far beyond a basic understanding of breath test technology. A DUI investigation is, in essence, a microcosm of the criminal justice system.

A quick peak at a cross-section of DUI files reveals that the professional legal practitioner will need to be fully conversant in:

- Examination or cross-examination of the police officer, focusing on;
- Driving evidence
- Legal issues surrounding grounds to stop, decision to arrest, and any demands or warnings given
- Observational evidence
- Standardized Field Sobriety Testing
- Drug Recognition Evidence
- Understanding of the batteries of tests, and their administration and interpretation
- Physical evidence of impairment
- Evidence and statements by witnesses or third parties
- Statements made by the accused
- Chemical or scientific evidence;
- Preliminary breath testing procedures
- Maintenance, operation, and calibration of the devices used
- Interpretation of any error messages
- Blood testing
- Physical collection and proper storage of blood samples
- Chain of custody issues for blood samples
- Gas chromatography of blood samples
- Urine testing
- Physical collection and proper storage of urine samples
- Chain of custody issues for urine samples
- Gas chromatography of urine samples
- Expert and opposing expert evidence, if any
- Medical issues or other issues affecting reliability of results
- The pharmacokinetics of alcohol or drugs
- General investigative actions by police
- Traffic Accident Collision Analysis
- Vehicle operational and equipment inspections by certified mechanics
- General crime scene investigations
- Autopsy reports including toxicological screens

Final Thoughts:

So, why is any of this important? Simply put, you need to be fluent in the language of DUI investigations in order to be effective. Statistics shows the sheer numbers of DUI arrests each year. Without a full understanding of the intricacies of the DUI investigation, including the science behind the testing process, you are at a disadvantage. You need to invest the time to learn about the science and technology in order to effectively and efficiently address issues head-on.



More to Explore:

“Crime in the United States, 2013”, website of the *Federal Bureau of Investigation, Criminal Justice Information Services, Uniform Crime Reporting*, downloaded July 5, 2015 from:

<https://www.fbi.gov/about-us/cjis/ucr/crime-in-the-u.s/2013/crime-in-the-u.s.-2013>

Perreault, S., *Police reported crime statistics in Canada, 2012*, Canadian Centre for Justice Statistics, Statistics Canada, Government of Canada, 2012.

McCabe, J., *An analysis of police department staffing: How many officers do you really need?*, The ICMA Center for Public Safety Management, downloaded July 26, 2015 from:

<http://icma.org/Documents/Document/Document/305747>

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An Introduction to Fuel Cells

They come in many designations: **PAS**, or *Passive Alcohol Screener*; **ASD**, or *Approved Screening Device*; **PBT**, or *Preliminary Breath Tester*. Sometimes they are simply referred to as *Roadside Testers*.

Regardless of what you call them in your jurisdiction, they all have one thing in common – they utilize a *fuel cell* to measure the **Breath Alcohol Concentration** (BrAC) in a breath sample.

In order to understand these devices, you first must know how a fuel cell works. This is a companion explanation to the article in this volume on roadside alcohol testers

What is a fuel cell?

Knowledge of fuel cells has been around for almost 200 years. A fuel cell is a device that directly converts a fuel of some sort into electricity through a chemical reaction inside the fuel cell itself. As long as there is a fresh supply of the source chemical used as fuel, energy will be produced until the reactant solution within the fuel cell itself is depleted. Obviously, we are most interested in fuel cells that use *ethanol* as the source fuel.

In 1967 Bill Ducie, a British electrical engineer, and Tom Jones, a chemistry professor at the University of Wales, joined forces and formed Lion Labs in the United Kingdom. Their development work resulted in the first *ethanol specific*, fuel cell device. The technology was incorporated into the Lion Alcolmeter® - the world's first fuel cell based breath alcohol analyzer. In 1989 Lion Labs merged with US based CMI Inc. Combined, it is now one of the world's largest developers and manufacturers of breath alcohol devices, including the Intoxilyzer® line of breath test instruments.



Figure 1 - The fuel cell from an Intoximeter RBT IV. It is about 35mm wide (almost 1½ inches wide).

A fuel cell is different than a battery

Fuel cells and batteries both produce electrical current, but do so in different ways. In a battery, the chemicals necessary to create the electrical current are all contained *within the battery itself*. Once one or the other of the two main chemical components of the battery is exhausted, the battery must be either replenished or recharged.

In a fuel cell, the fuel source is *external* to the cell. As long as there is a source of fuel (and the *chemical reagent* is fresh inside the cell), the fuel cell will continue to produce an electrical current.

Fuel cells versus semiconductors

Older roadside screening devices, and some of the so-called “mini key-chain Breathalyzers” currently available, use semiconductor detectors to analyze for the presence of ethanol. Gas sensing semiconductors have been around for about 40 years. Semiconductors are very different from fuel cells. As their name implies, the detector uses semiconductor technology to measure the presence and concentration of ethanol.

As ethanol is introduced into the device, the conductivity of the semi-conductor (meaning the amount of electricity that flows through the device) decreases. More ethanol means a greater increase of electrical resistance, which decreases the conductivity of electricity.

If a current of a known value is then passed through the semiconductor, the drop in the electricity can be measured. This forms the basis for taking a BrAC measurement.

The semiconductors are subject to substantial drift in readings over a short period of time, and are very influenced by both ambient temperatures and atmospheric conditions. In general, they are no longer considered reliable technology for investigative purposes.

Advantages of fuel cells over semi-conductor technology

The use of fuel cells as an analytical sensor over older semiconductor technology offers a number of advantages:

- A greater degree of *specificity* towards detecting ethanol; Semiconductors could provide false-positive readings for substances other than ethanol;
- Semiconductors are sensitive to changes in altitude or atmospheric pressure;
- The response of the fuel cell to ethanol is a direct linear relationship;
- Fuel cells offer a longer working life;
- Less frequent calibrations are required in fuel cells;
- Fuel cells require heating only at low ambient temperatures, therefore battery life of the units is longer.

How fuel cells are designed

Imagine an OREO® cookie. The fuel cell has a similar design. The core represented by the inner icing is made from a porous ceramic material. The ceramic core will eventually be saturated with an acidic solution that will chemically interact with the ethanol. The ceramic core will be painted on both sides, represented by the outer sandwich wafers, with either porous paint containing “platinum black”, or a porous platinum disc.



Figure 2 – Porous disc with platinum black coating forming the fuel cell.

A sample chamber that holds about 1 millilitre (1mL) of air is now attached to one side of the “cookie”. The other side is open to the room air. The platinum black paint will allow room air to penetrate the coating on one side, and a breath sample containing ethanol from the sample chamber to penetrate on the other side. Molecules of ethanol can now get into the fuel cell where they will be oxidized inside the cell. The cell also conducts electricity, so wires are attached to either side, and are sent to a device that reads the electrical activity produced by the fuel cell. Fuel cells are quite small (about the size of a dollar coin).

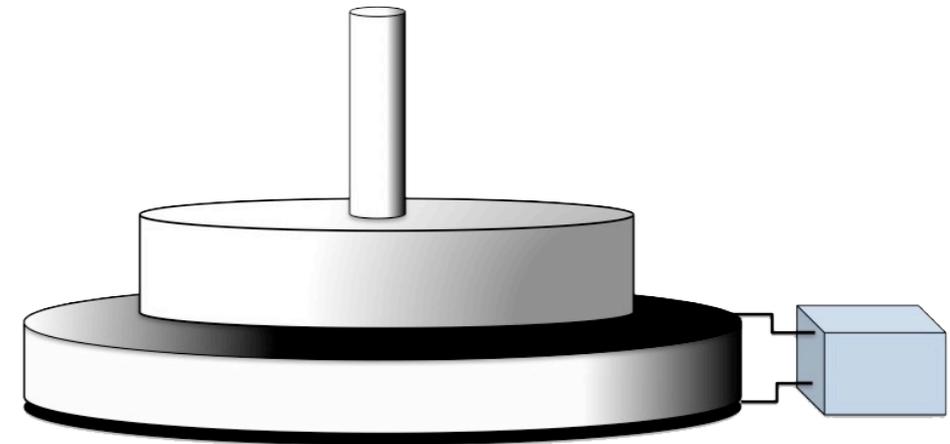


Figure 3 – Fuel cell with sample chamber attached (top) with electrical wires out to a microprocessor.

I hope you have noticed that these articles have been referring to **BrAC** (*BREATH* alcohol concentration) as opposed to **BAC** (*BLOOD* alcohol concentration). *Try and get into the habit of differentiating the two measurement types.* Breath alcohol testers measure breath alcohol concentrations.

What happens inside a fuel cell?

Fuel cell sensors are true electrochemical devices. They *oxidize*¹ the substance to be analyzed, in this case ethanol, on a catalytic surface – the platinum electrode. The platinum electrode forms the *anode*² of the fuel cell. The other side of the cell reduces atmospheric oxygen at the platinum *cathode*³ – the counter electrode in the cell.

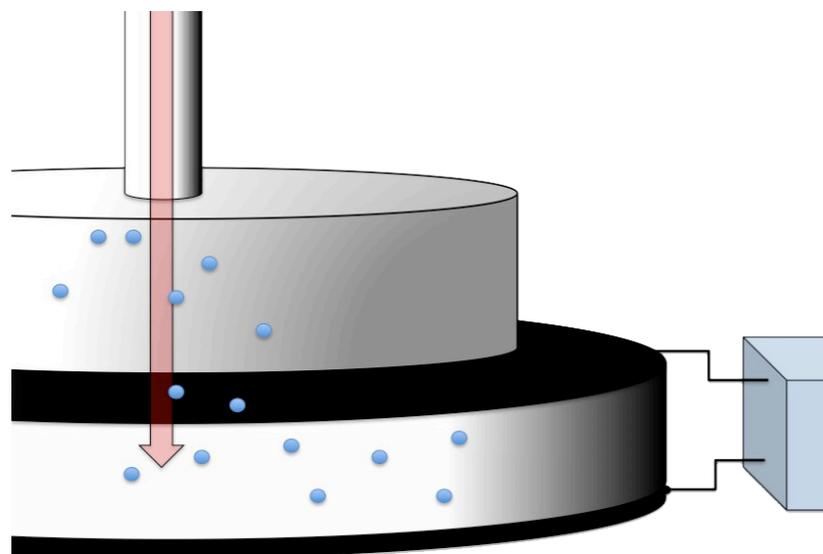


Figure 4 – Ethanol molecules collected in the sample chamber enter the fuel cell, where they will be oxidized by the chemicals impregnating the cell.

The two platinum electrodes are separated and supported by a thin porous ceramic disc that is impregnated with a *reagent* - an acidic electrolyte solution. The fuel cell oxidizes *ethanol* into *acetic acid*.

The fuel cell is designed to produce a self-sustaining oxidation of ethanol at the cell's negative pole, initiating electron flow and therefore current generation to the cell's positive side. Basically, it becomes a battery producing an electrical current.

¹ To **oxidize** in this case is to remove one or more electrons from the compound in question.

² The **anode** is the positive electrode of the device, the point of departure for the electrical energy from the fuel cell. Think of it as the “+” pole of the battery.

³ The **cathode** is the negative electrode of the device, the point of entry of electrons into the fuel cell. Conversely, this is the “-” pole of the battery.

Quantifiable fuel volume produces a measurable reading

The only two variables we have are the volume of sample introduced, and the concentration of ethanol in the sample. Ultimately, the roadside tester will control the breath sample through the *volume of its sample chamber*. See “*The Breath Sampling System*” in the article on Roadside Screening Devices in this issue. This leaves only the ethanol concentration as a variable⁴.

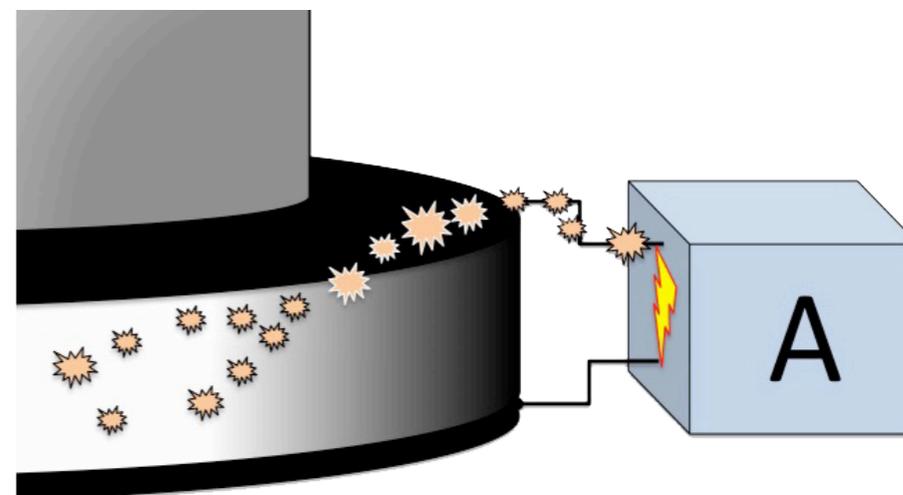


Figure 5 – The ethanol molecules are oxidized in the fuel cell. Each molecule will release an electron, creating a flow of electrical current. Since the volume of the sample chamber is known, the amount of ethanol in the sample becomes the only variable. The unit is calibrated to know that a certain current produced is equivalent to a specific BrAC reading.

More ethanol molecules in the sample chamber ultimately produces more electrical current. Therefore the unit must be initially calibrated to know that a specific concentration of ethanol is equivalent to a specific electrical current. This electrical current is now correlated to a specific Breath Alcohol Concentration (BrAC) reading.

⁴ Well, yes and no... There is a codicil to this, but we will leave that for a later article. I've given a brief explanation on Page 43 in the section on “calibration and drift”.

How large is a breath sample in a fuel cell device?

Fuel cells don't require a large sample by *weight* in order to generate enough electrical energy to create a reading. In a roadside breath test device, as an example, a BrAC reading of 0.08 grams will be created with only 0.00000038 grams of ethanol in the test chamber¹. In scientific notation, that is 3.8×10^{-7} grams of alcohol. In other words, this is about 4/10-millionths of a gram by weight.

How large is a gram? Well, as an example, a small paper clip weighs a gram. So does a brand new U.S. one-dollar bill. Imagine taking a fresh, new one-dollar bill, cutting it into 10 million pieces, and weighing 4 of those pieces. *That is how much a 0.08 gram BrAC sample weighs in the test chamber of a roadside tester.*

But, to be fair, there are an enormous number of *molecules* of ethanol in that size sample because molecules are exceedingly tiny things. I'm not going to bore you with the nerdy calculations, but a 0.08 grams BrAC ethanol reading in a 1 millilitre sample chamber has 4.9×10^{15} molecules of ethanol (almost *5 quadrillion* molecules).

A quadrillion is probably something you've never heard of - *it is a million groups of one thousand-million each*. The sample therefore contains almost 5 million-billion molecules. In other words, a LOT of molecules...

So we see, you are measuring an exceedingly small *weight* of ethanol in the sample chamber of a fuel cell device to produce a reading at the legal limit. However, it also takes very little contamination to produce a false positive reading, or very little loss of the sample to produce a falsely low reading.

¹ Assuming a one-millilitre sample chamber, and a 2100:1 blood-to-breath calibration ratio, with the sample at 20°C, at 1 atmosphere pressure.

Issues with fuel cells

Lag time

There must be a suitable delay between tests to allow residual waste acetic acid to be purged from the fuel cells. On some models of roadside testers, pressing the READ button for approximately twenty seconds drains the fuel cell and purges any residual electrical current. This may need to be done a number of times, depending upon the residual chemicals from the last sample obtained.

On other models, an automatic delay is built into the micro-controller circuitry that cannot be operator bypassed. This prevents additive reading errors caused by residual acetic acid from previous tests. With zero or very low ethanol levels, the time required to purge the residual ethanol will be very short. Higher readings require a longer time interval between tests.

Fuel cells take about 20-30 seconds after capturing the sample to reach their peak electrical response, which indicates the reported BrAC of the donor. During this time, the operator may be holding the "READ" button as on the Intoxilyzer Model S-D2, or waiting for the "Analyzing" light to go out, as with the Intoxilyzer Model 400 or Intoximeter VXL.

Ambient temperature

The units are calibrated at room temperature. Since the process is in essence a chemical reaction, it is dependent upon the ambient temperature, as are all chemical reactions. If the ambient temperature is lower, the reading is lower than expected. Conversely, if the ambient temperature is higher, the resulting reading will be higher than expected. *More on this, with supporting data, in a later article.*

Specificity overview

Ethanol fuel cells are primarily sensitive to ethanol. It is believed that they do not provide a strong false-positive BrAC from compounds other than ethanol. For now, know that the fuel cells will have a response to the other alcohols – methanol and isopropanol. However, we will discuss in future articles that discuss the issue of *specificity*.

Calibration & drift - An important consideration

It must be noted that each time the fuel cell analyzes an ethanol sample, a portion of the acidic reagent impregnating the cell is oxidized, as discussed above. The net effect is that, over time, the fuel cell will become *less* sensitive to ethanol, producing *less* electrical current, and will need to be calibrated. Calibrating the device merely means teaching it that the new lower current produced is now equivalent to a desired BrAC reading.

This points to the necessity of bi-weekly calibration checks of roadside screening devices, correcting and calibrating them when necessary. Eventually, the fuel cell will use up the bulk of its available acidic reagent solution, and will become unstable. Calibration checks will be erratic. Eventually, they become unable to be calibrated.

I've seen units that cannot be calibrated due to a spent fuel cell. Unfortunately, they seem to behave in an erratic fashion towards the end of their serviceable life, and may not be identified as unreliable during operation or calibration. They can drift high or low in successive readings compared to a known value. This is one reason why annual maintenance and monthly – or more often – calibration of the devices is necessary. It also points to the need of maintaining a calibration log, so that the performance of the device can be monitored.

Fuel cells in other devices

Ignition interlock devices also utilize fuel cells to determine the presence and concentration of ethanol as well. They also need periodic calibration, particularly since they are designed to read ethanol levels at low thresholds – around between 0 - 0.020 grams.

Fuel cells are also used in some evidentiary instruments as well. This is done in two ways:

Use of a fuel cell as an evidentiary instrument:

In certain jurisdictions, California for example, the Preliminary Alcohol Screening (PAS) device can be subsequently used as an Evidentiary Test (EPAS) after waiting until the end of a 15-minute deprivation and observation period. The same device is then used to perform two breath tests, three-minutes apart. The device must be able to print out the results. Theoretically, the same device is used for both the preliminary and subsequent evidentiary tests.

Use of fuel cells in dual-instrumentation technology:

In certain evidentiary instruments, *two* forms of analysis are performed on the breath samples received. Both an *infrared* (IR) measurement, and an *electrochemical* (EC) measurement made by the fuel cell are obtained. Often, the IR measurement is used to determine the suitability of the sample, with the captured sample then analyzed by the fuel cell to produce a BAC result. If the results are within acceptable agreement standards, the final BAC is reported.

This dual-analysis system has some advantages in terms of the specificity of the ethanol reading, and the overall reliability of the process. However, sometimes options are disabled on the devices, so understanding the setup and operational characteristics of the device are necessary to determine the overall reliability of the numerical results obtained.

Final Thoughts:

Fuel cell technology has evolved to the point where they can provide fairly accurate and reliable breath alcohol results under normal circumstances. However, they are often used by operators with less training than Evidentiary Instrument operators. Additionally, the devices are often less sophisticated, with fewer safeguards built in. Finally, it must be kept in mind that the fuel cell cannot provide a continuous, real-time measurement *while* the sample is being provided. Instead, they trap a sample, and analyze it, subsequently reporting the BAC reading as a snapshot in time.



More to Explore:

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“Intoxilyzer 400 Operating Manual”, CMI, Incorporated, Owensboro, Kentucky, 1996.

“Intoxilyzer S-D2 Operator’s Manual”, CMI Incorporated, Owensboro, Kentucky, 1998.

“Intoxilyzer S-D5 Operator’s Manual”, CMI Incorporated, Owensboro, Kentucky, 2002.

Everyone is a
genius. But if you
judge a fish on its
ability to climb a
tree, it will live its
whole life believing
that it is stupid.

-A Einstein



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Glossary of terms

Acetic Acid – Also called ethanoic acid, because it is a byproduct of ethanol. (Remember, vinegar, or acetic acid, was first discovered when wine spoiled and was oxidized.) Acetic acid is an organic compound with the chemical formula $C_2H_4O_2$. Ethanol is converted to acetic acid in a fuel cell. Interestingly, ethanol is also converted into acetic acid in humans by the metabolic action of ADH enzymes. *See the article on Standard Drinks, in this issue.*

Anode - The positive electrode of the device, the point of departure for the electrical energy from the fuel cells. Equivalent to the “+” pole of a battery.

Calibration – To compare and CORRECT a measurement against a known standard.

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

Cathode- The negative electrode of the device, the point of entry of electrons into the fuel cells. Equivalent to the “-“ pole of a battery.

Fuel Cell Sensor– A device that converts in direct proportion the molecules of ethanol in a breath sample into an electrical current.

Oxidize- The removal of one or more electrons from the compound in question.

Reagent – Used in the fuel cell to react with the ethanol in the subject’s breath. The reagent solution is contained in the fuel cell, and is comprised of a mixture of acidic chemicals that produce an electrical current upon contact with an alcohol.

Volatile- Volatile refers to evaporating quickly and easily at room temperature. Because of its lower boiling and evaporation point, alcohols will evaporate spontaneously at room temperatures. A substance must be volatile to exist on the breath of a subject, hence the inability of breath testing devices to read levels of other substances such as drugs or marijuana.

An Introduction to Standardized Field Sobriety Testing



Shortly after midnight in the early hours of September 10th, 1897, 25-year old British taxi driver George Smith made history. Just three weeks after the first motorized taxis began service in London, Smith drove his cab into the side of a building at the then breakneck-speed of 8 mph, bursting a water pipe and smashing a window in the accident.

The incident was witnessed by foot patrol Constable Russell, who would also make history that day in the world's first reported DUI arrest.

In Brief:

This article will introduce the Standardized Field Sobriety Tests. This will provide an overview of the tests, how they are to be administered and graded, and some of the background implications of the testing. *It lays a groundwork for future articles that will discuss each test in depth, along with the underlying validating studies and science involved.*

When new technologies create emerging issues



Figure 1 - One of London's original electric cabs, circa 1897

Constable Russell determined that Smith was drunk at the scene of the accident. The newspaper accounts of the day report that Smith claimed to have consumed only two or three beers (*yet another first!*).

Constable Russell arrested Smith – and thus history's first DUI investigation began. The Police Surgeon was summoned; Smith was examined and determined to be drunk.

Smith subsequently plead guilty, and received a fine of 20 shillings from the local Magistrate. That amount is equivalent to about USD \$175 in today's value.

It is unfortunate that the newspaper account does not report on the signs of impairment Constable Russell observed. However, we can be fairly certain that the empirical tests, if any, that Constable Russell or the Police Surgeon used to determine Smith was drunk probably did not look anything like the field sobriety tests we use today.

DRUNKEN MOTOR CAB DRIVER.

At Marlborough-street Police-court yesterday George Smith, aged 25, of Portnall-road, Harrow-road, was charged by the police with being drunk when in charge of a motor car, of which he was the licensed driver. Police-constable Russell, 247 C, stated that at a quarter to one that morning he saw Smith in Bond-street in charge of a motor-car—a four-wheeled electric cab. Suddenly the vehicle swerved from one side of the road to the other, and ran across the footway into 165, New Bond-street, breaking the water-pipe and the heading of the window. Thinking that driver was unable to manage the vehicle, witness asked him to get down from the box, and finding that he was drunk, took him to Vine-street Police-station. He then denied being drunk, and the divisional surgeon was sent for, who certified that he was drunk. Prisoner: How fast was I going? Constable: I should think about eight miles an hour. Prisoner: At the time I was going up an incline, and could not have been going six miles an hour. The fastest these cars can travel is eight miles an hour. Mr. De Rutzen: You are not charged with driving furiously, but with being drunk. What about that? Prisoner: I have nothing to say to that. I admit having had two or three glasses of beer. I am very sorry. It is the first time I have been charged with being drunk in charge of a cab. Mr. De Rutzen (looking at the list of convictions sent from Scotland Yard): You appear to have been charged here with being drunk. Prisoner: Yes, but that was not when in charge of a cab. Mr. De Rutzen: You motor-car drivers ought to be very careful, for if anything happens to you—well, the police have a very happy knack of stopping a runaway horse, but to stop a motor is a very different thing. There will be a fine of 20s.

Figure 3 - London newspaper account, Sept 10, 1897

Standardized Field Sobriety Testing

Field sobriety tests have been around in one sort or another almost as long as people have been operating cars after consuming alcohol. However, they were tests created on an *ad hoc* basis without underlying data to support their conclusions. In 1975, the National Highway Traffic Safety Administration (NHTSA) commissioned a study by research psychologists Dr. Herb Moskowitz and Dr. Marceline Burns from the Southern California Research Institute. They were tasked with studying and evaluating the sobriety tests used by police in the US at the time. Sixteen tests were originally evaluated. NHTSA wanted a set of reliable and standardized tests that had the basis of scientific rigor supporting their conclusions. By the end of the study, the three tests chosen are the same ones we've used for the last 35 years.

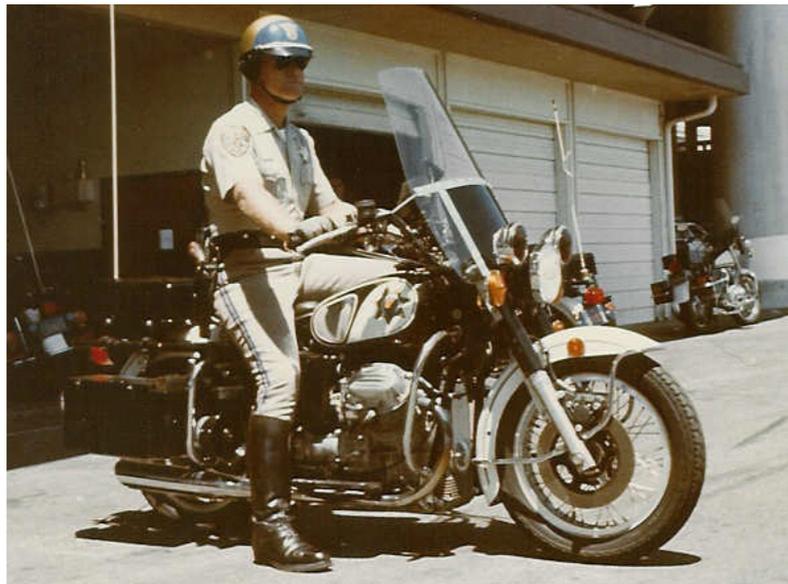


Figure 3 - California Highway Patrol Officer, circa 1975

Standardized Field Sobriety Tests (SFSTs) are designed to help an officer establish the legal grounds necessary to believe impairment was present. But, with initially a 47% margin of error, they were not without their problems. They need to be performed and evaluated in a *precise and reproducible* way, each time they are given. Keep in mind at the time the legal limit, and therefore the presumption of impairment, began at .10 - .15 grams/100mL, depending on the jurisdiction.

Moskowitz and Burns concluded that the initial margin of error was high because officers either didn't conduct or evaluate the tests correctly, or that they ignored evidence of factors other than alcohol. The problem is in establishing evidence of physical *impairment* for a person between 0.08 grams to the point that gross signs of *intoxication* emerge at higher BACs.

As a result of the standardization of the tests, training curricula was devised to teach the officers to conduct these tests *exactly* in a prescribed manner. If the officers do not administer the tests as prescribed, and evaluate the performance of the subject in a standardized manner, their findings are not reliable. They must compare the observed results of the test subject against the statistically established normative values of the prior known and validated test subjects. Any clues observed in the performance of the tests are supposed to lead an officer in an exercise establishing the statistical likelihood of a blood alcohol concentration above a certain number, in comparison to the validated test subjects.

In essence, by having one set of instructions and evaluation criteria, the performance by a test subject could then be compared to previously tested, validated and expected results. Any deviation from the test performance would then assist the officer in forming the opinion of the statistical likelihood that impairment exists.

The officers are taught to conduct their investigations in three phases:

1. Vehicle driving observation phase
2. Initial contact with the motorist phase
3. SFST testing phase

“If the officers do not administer the tests as prescribed, and evaluate the performance of the subject in a standardized manner, their findings are not reliable.”

The Vehicle in Motion – Phase One

Most often, the first line of investigation for an officer is the actual observation of the vehicle in motion. Officers are taught to concentrate on gathering all relevant evidence that may suggest impairment. This includes vehicle equipment and licensing infractions, moving violations, and unusual driving actions. Roughly speaking, the officer is looking for one or more of the following clues to support a traffic stop:

1. Speed violations – either too fast or inappropriately slow
(10 mph or more under the speed limit is considered too slow)
2. Weaving, or improper or unsafe lane usage or drifting;
3. Braking issues;
4. Wide turns, or sharp sudden movements;
5. Near collisions with objects, vehicles or pedestrians;
6. Improper turns; inconsistent or lack of signaling;
7. Slow response to traffic signals;
8. Slow response, or failing to respond at all to the officer's signals;
9. Driving without headlights at night;
10. Stopping or starting for no apparent reason; and
11. Following too closely.



Certainly, none of these are specific indicia of impairment. Some people are distracted while driving for other reasons, and others are just bad drivers, but they do give the officer an articulable reason for initiating the traffic stop.

Personal Contact – Phase Two

Once the decision is made to stop the vehicle, a safe place should be chosen before initiating the vehicle stop, whenever possible. We need to acknowledge the fact that traffic stops present one of the highest safety hazards for officers. Officers learn quickly in the field from stop after stop that the safest course of action is approaching the vehicle like you would approach a coiled snake. You just don't know what situation you will be dealing with during the stop.



As they approach, they begin to interview and observe the driver, and any passengers. Officers are taught to use their sight, their hearing, and their sense of smell during the initial contact phase. Among other things, officers are taught to look for the following physical indicia of alcohol consumption or impairment:

1. Bloodshot or watery eyes;
2. Alcohol containers in the vehicle;
3. Unusual actions;
4. Fumbling with objects or while retrieving papers;
5. Signs of slurred speech;
6. An admission of drinking alcohol;
7. Inconsistent or incoherent responses;
8. Unusual comments or abusive language; and
9. The smell of alcoholic beverages, marijuana, or cover-up odors.

Divided Attention Deficit

Divided attention is when you must perform two or more tasks at the same time, and your attention is required to perform both tasks correctly. For example, driving a car, eating dinner while watching TV, or reading this article while thinking about today's to-do list are all examples of divided attention tasks. When people are required to do more than one task at a time, the performance of either one or both of the tasks often declines. It is believed that our perceptual systems have limited resources and are incapable of processing multiple stimuli. If your performance on one or both of the tasks is compromised, you are thought to have *Divided Attention Deficit*.

During this phase, officers are taught to initiate simple a divided attention situation, by:

1. Asking for two things simultaneously;
2. Asking interrupting or distracting questions; or
3. Asking unusual questions.



When police see that the driver is unable to process the confusing, distracting or unusual demands, or ignores the questions altogether, they are taught to use some additional techniques to determine the level of divided attention. For instance, counting backwards to a certain number places a burden on a person, because they have to both count backwards, and remember where to stop counting.

Similarly, reciting the alphabet from the letter E to the letter P, without *singing that song*, divides the attention because most people can start from the letters A through Z without thinking twice about the task, *especially while singing the song that is going through your head right now*. Retrieving a driver's license, registration and proof of insurance while discussing where the driver was coming from, or what they had for dinner all place demands on the driver's attention level.

As they have the driver get out of the car, officers are looking for signs of balance issues, unsteadiness, or using the car for balance. Finally, before beginning the battery of SFSTs, officers are supposed to perform what is referred to as "pre-arrest screening." This should begin with a roadside preliminary breath test, if one is available. Questions are often asked that are supposed to pre-screen the subject for any underlying medical conditions.

Phase Three - Standardized Field Sobriety Testing

The tests are designed to focus on physical impairment based on the consumption of alcohol as much as possible. These are the three *Standardized Field Sobriety Tests* administered:

Horizontal Gaze Nystagmus (HGN)



Horizontal Gaze Nystagmus is the naturally occurring involuntary jerking of the eyes as they move side to side while following a moving object. It is thought that when a person is impaired by alcohol, the nystagmus is magnified or pronounced. When sober, the eye movement is smooth and relaxed.

In the HGN test, the officer observes the eyes of a suspect as they follow a slowly moving object such as a fingertip, pen, or penlight (the “stimulus”) in a slow horizontal movement. The subject is instructed to stand with their hands at their sides, and their feet together. The stimulus is held 12-15 inches in front of the subject’s nose, with the focal point slightly above the eyes. As the suspect tracks the stimulus with the head remaining stationary, the officer observes indicators of impairment in each eye:

Before the scoring phase of the HGN begins, the officer must pre-screen the subject to ensure that they can, in fact, track the stimulus. They should also perform a number of very slow tracks to see if there is any visible, naturally occurring resting nystagmus.

Officers are looking for three clues, one in each eye for a total possible score of 6:

1. *Lack of smooth pursuit of the object;*
 - a. The officer moves the object slowly and steadily from the center of the subject’s face towards one of the ears.
2. *Distinct nystagmus when the eye is at maximum deviation* (maximum deviation means the eyeball moves horizontally as far as it can go);
 - a. The pen or object is brought from the center of the face to the tip of one ear, and held for four seconds. The test is then repeated on the other side. No jerking of the eye (saccadic eye movement) should occur
3. *An angle of onset of nystagmus prior to 45 degrees from center;* (45 degrees being approximately when the eye is near the subject’s shoulder blade).

The subject does not have to see the object clearly to perform the HGN test. The subject just has to see the object well enough to be able to follow it with his eyes. Blurry vision is not a medical condition that prohibits the subject from taking the test or performing satisfactorily.

Scoring

Officers are taught that in suspects exhibiting any of these cues, there is a 88% probability that they have a BAC exceeding .10 grams/100 mL.

The Walk & Turn, and the One-Leg Stand Tests

The *Walk & Turn Test* and the *One-Leg Stand Test* must be administered on a hard, dry, and non-slippery surface, and in a well-illuminated area. Both of these tests are considered to be “divided attention” tests, in that they challenge the subject’s short term memory, judgment and decision making skills while imposing a psychomotor component. Simplicity is the key in the tests. They need to be simple enough that sober people can perform them, but hard enough that they trigger clues of impairment. *If they are too hard for sober people to perform in the first place, they have no evidentiary value.*

Officers are also taught that people more than 65 years old, over 25 kilograms (50lbs) overweight, or with physical impairments that affect their balance should not be given the test.

The Walk & Turn Test

There are two components to the Walk & Turn test:

- Specific instructions, and
- Performance (walking).



In the first stage, the subject is instructed to stand in the “Ready Position”, on a line with their feet in the heel-to-toe position (right foot in front of left), and too keep their arms down at their sides. They are told to listen to instructions and not begin until being told. The subject is instructed to take nine steps, heel-to-toe, along a straight designated line while counting the steps out loud and watching their feet, and then turn in a specific way (non-pivot) and return in the opposite direction.

The officer is trained to look for these 8 signs of impairment:

During the Instruction Stage:

1. The subject loses balance during the instructions
(by breaking the heel-to-toe stance)
2. The subject begins walking before the instructions are completed

During the Walking Stage

3. The subject stops while walking to steady themselves
4. The subject does not touch heel-to-toe
(by missing by at least a centimeter or more)
5. The subject steps off the line
6. The subject uses their arms to assist in balance
(by raising them 6 inches or more)
7. The subject makes the turn not as shown
8. The subject takes the wrong number of steps.
Remember, they’ve been shown *three* steps out and back,
but told to do *nine*.

Officers should use a straight line that is visible to the suspect. *I’ve heard some fairly humorous cross-examination regarding the width of the imaginary lines.* The tests cannot be performed while wearing shoes with heels more than two inches high, and as such, the subject should be given an opportunity to remove their shoes if possible. Since this is impractical in many areas during winter months, officers sometimes omit this testing sequence.

Scoring

Officers are trained that if a suspect exhibits two or more of the eight possible clues, there is 79% probability that they have a BAC exceeding .10 grams/100 mL.

One Leg Stand Test

As with the Walk & Turn test, there is an instructional component, and a performance evaluation.

During the Instructional Phase

In the instruction stage, the suspect must stand with their feet together with their arms at their sides. They are to listen to the instructions and not begin the test before being told to do so.

During the Performance Phase

The subject is instructed to stand with one foot of his choice approximately 6 inches off the ground, toes pointed out, and count aloud by thousands (One thousand-one, one thousand-two, etc) while looking at the elevated foot until told to put their foot down. The suspects are told not to hop or sway and not to use their arms for balance.

The officer should look for signs of impairment, including:

1. Swaying while balancing
(a noticeable sway in a side to side or back and forth motion)
2. Using arms to balance
(arms must raise from sides more than six inches)
3. Hopping to maintain balance, or
4. Putting the foot down

The officer conducting the test should remain motionless and stand about a metre away from the suspect, and be prepared to catch them if they lose their balance. Officers should time the subject for a full thirty seconds if possible. The original 1977 validation study showed that many impaired subjects were able to stand on one leg for 25 seconds, but that few were able to do so for a full 30 seconds.

Scoring

Officers are trained that if a suspect exhibits two or more cues, there is a 83% probability that they have a BAC exceeding .10 grams/100 mL

Field sobriety testing must be done in a standardized fashion to be validly interpretative. Other tests, such as counting backwards, picking up objects such as coins, and simple math, are not standardized; therefore, no valid basis of comparison may be made. It is the *standardization* of the tests that offers the articulable reasonable and probable grounds to believe impairment is present, as performance is based upon a known standard. The probabilities of impairment are based upon statistical evaluations. To be sure, many individual physical factors may negate the validity of the tests.

Some Final Thoughts:

Let's return to our London cabbie, George Smith, for a minute. We do know that local authorities summoned their Police Surgeon to examine the London cab driver, who determined Smith was drunk. History doesn't record his Blood Alcohol Concentration (BAC), but I would hazard a guess that Smith was *intoxicated* as opposed to *impaired*. The first generally enacted legal limits for alcohol levels were 0.15 grams/100 mL of blood. The indicia of *intoxication* at that level are fairly pronounced. As BAC limits drop lower and lower, the ability to detect lower levels of *impairment* becomes more critical.

We will examine these issues in depth when we look at physical signs of impairment and intoxication, the effects of tolerance, and BAC level charts in future articles. ▲

Comparison of SFST Accuracies 1981 vs. 1998

It is the administration and scoring of these tests that is the critical component. Officers must give the directions properly and according to the standard, and they must score the tests properly and according to the standard. If the directions are given incorrectly, the test subject should not be penalized for poor performance. The same applies to substandard scoring.

	1981, Tharp et al	1998, Burns et al
BAC	0.10 grams/100mL	0.08 grams/100mL
HGN	77%	88%
WAT	68%	79%
OLS	65%	83%
Combined	81%	91%

What the officers are in essence doing with these tests is creating a mathematical probability. They observe the test performance and compare it to the known and validated performance standard. If the subject cannot perform the test according to the standard, the officer relies on the statistical probability that the subject has a BAC above .08 grams.

For instance, 2 or more clues out of 6 on the HGN leads the officer to believe the subject has an 88% chance of having a BAC of .08 or greater. Two or more clues out of eight on the Walk & Turn test, they are trained that 79% of validated subjects will have a BAC exceeding .08, etc.

Notice how the probability values have changed... Why? We will look at the validation studies as well in future articles.

NHTSA Studies: Tharp, Burns, & Moskowitz (1981)
Burns & Stuster (1998)

More to Explore:

DWI Detection and Standardized Field Sobriety Testing Participants Guide, NHTSA and IACP joint publication, March 2013 Edition.

Stuster, J., and Burns, M., *Validation of the Standardized Field Sobriety Test Battery at BACs Below 0.10 Percent*, report of Anacapa Sciences, Inc., Santa Barbara, CA., Prepared for NHTSA, August 1998.

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Establishing a Professional Learning Community

Susan Reschny, M. Ed.

A few years ago, I had the opportunity to meet a young lawyer at an internationally attended DUI conference being held in Toronto, Canada. At a break, this “new to the bar” practitioner confided to me that she was very nervous about attending with so many experienced lawyers and experts in the field, particularly because of the scientific nature of the content.

Her binder was already covered in colorful sticky notes demonstrating her studious diligence, but despite her effort, she still had many questions that she was afraid to voice.

Unfortunately, she feared her questions were too simplistic for, what she perceived was a much more sophisticated group of attendees. Besides, she explained, she had chosen to study the law because “*science just wasn’t her thing...*”

She is not alone.



The Need for Continuing Education

Continuing education is a required element for many professional designations. Within the context of our chosen fields, we regularly attend seminars and conferences to stay current and to prove we have done our due diligence. These types of continuing education venues often provide expert lectures on various topics to large groups of people. Asking clarifying questions in this educational environment may be perceived by learners to be difficult or impossible and for some, like the young lawyer from Toronto, very intimidating. For most of us, this traditional method of learning from experts, usually lecture style, began in classrooms at a very young age, but educational researchers are beginning to realize that passive exposure to information is not an optimal way to learn.

Why Establish a Professional Learning Community?

The terms Professional Learning Community (PLC) or Networked Learning Community (NLC) have been used primarily by educators and refer to a movement promoting collaboration between teachers to improve student learning. Dr. Shirley Hord (1997) from the University of Texas at Austin, suggested PLCs and other professional learning models in the private sector were significantly influenced by Peter Senge's 1990 book, *The Fifth Discipline*.

In his book, Senge posited an idea of learning opportunities “where people continually expand their capacity to create the results they truly desire, where new and expansive patterns of thinking are nurtured, where collective aspiration is set free, and where people are continually learning how to learn together”(p.3). In public education, PLCs have become vehicles for change, providing educators opportunities to engage in conversations surrounding new research and ideas to better serve their communities.

Although lawyers have collaborated with colleagues and participated in continuing education through requirement and choice, creating a professional learning community may offer a new learning paradigm. Like teachers in classrooms, lawyers often work in isolation as sole practitioners, selecting a focus and choosing arguments to best serve their clients. Although individuals may tap the experiences of others through consultation, decisions and directions are often determined autonomously, especially in private practice.

Professional Learning Communities (PLCs) are not created to take the place of learning opportunities such as conferences, but they have the potential to offer a more engaging venue to pursue a different kind of learning experience. According to Kristi Garrett, a staff writer for California Schools (2010), “A PLC is distinguished by three key elements: a focus on learning, professional collaboration, and a focus on results (p. 5)”.

“A Professional Learning Community is distinguished by three key elements:

- *a focus on learning,*
- *professional collaboration, and*
- *a focus on results.”*

Unlike traditional learning opportunities, PLCs target issues and encourage creative engagement and collaboration within their membership. A Professional Learning Community offers the profession timely, relevant learning opportunities that could lead to reform. “The encouragement, expertise, and support of colleagues in the learning community create a team even more resilient than the strengths of its individual experts (Garrett, 2010, p. 6)”. Considering the present social climate, perhaps a strategic and collaborative approach to legal issues could be beneficial.

PLCs versus traditional learning opportunities

How are PLCs different from more traditional learning opportunities?

Shirley Hord (2009) outlined six research-based dimensions of professional learning communities:

1. Shared beliefs, values, and vision:

PLCs work best when the group is driven by common beliefs, values and vision. Developing synergy within the group directs creative energy toward common challenges and solutions. The community determines best practice *“in alignment with a mental image of what new strategies and processes would look like when implemented in a high-quality way”* (Tobia & Hord, 2012, p. 20.) Through shared vision, practitioners are able to focus their collective experiences, knowledge and ideas and create questions for further study.



2. Shared and supportive leadership:

In a PLC, leadership, power, authority and decision-making are distributed across the community. This allows for new ideas, generating an environment of creative synergy. Although those practitioners who have more experience in the field may also have more practical knowledge, this type of learning opens the floor to those who are seeing issues with fresh eyes, thus merging and clarifying perspectives.

3. Supportive structural conditions:

The current economic environment has challenged all of us, but it is those beginning their careers, and those who are managing a busy caseload who are often unable to afford travel and conference expenses or time away. PLCs offer alternatives to traditional learning. The diverse nature of this type of community allows for innovative resource and venue options, ranging from mLearning, with online study groups to informal meetings at local restaurants to share ideas about pre-determined topics.

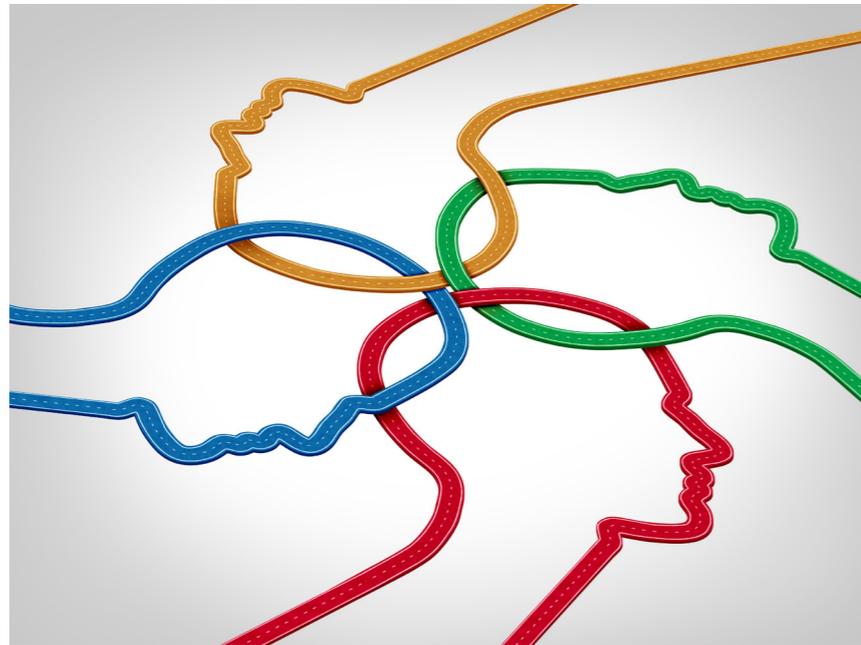


4. Supportive relational conditions:

PLCs establish a support group for professionals, where questions are expected and true relational bonds begin to form. This type of community thrives on trust, allowing professionals to ask the difficult questions and seek answers among their peers and mentors. PLCs are not places to advance political connections, or broker deals. These learning communities are places to advance individual and professional knowledge.

5. Collective learning:

PLCs focus learning choices intentionally. Topics are purposefully determined to address clients' needs and to increase the effectiveness of the profession. By reviewing data and engaging in meaningful conversations of common concerns within the community, PLCs can discover themes for inquiry. Together, practitioners can find ways to access experts to address background information necessary for making informed professional decisions.



6. Peers sharing their practice:

PLCs also offer members a venue to gain feedback from their peers and mentors. Through conversations surrounding the everyday and more challenging aspects of their career, individuals and the profession as a group can develop and improve. PLCs connect people with a common goal to improve their practice. PLC work and learning should be focused, productive, effective, and professionally stimulating. This targeted and inclusive method of learning has the potential to be very rewarding and effective. Members can affect positive change to their practice and profession by approaching continuing education through collaborative inquiry about topics that will directly improve the outcomes for their clients.

Creating a Professional Learning Community

Creating a community of learners can be accomplished in any profession. Although there are many different ways to approach this task, the following outlines the basic attributes necessary to promote this model of collaborative and focused learning:

1. **Establish a group of learners.** Determine a venue for the group and invite colleagues to participate in the learning experience.
2. **Identify a focus based on data or practical experience.** Through authentic conversation, observation and collected data, determine an inquiry or phenomenon to be examined. This focus should, ideally, have a direct effect on outcomes for the people or principles you represent.
3. **Share learning and experience.** The group of learners share their knowledge and observations, and access experts in the field to address the question or focus determined by the group.
4. **Develop a strategy to affect change.** With the end result of improved practice in mind, the PLC develops a strategy or course of action based on their conversations and learning.
5. **Implement the strategy, provide feedback to the group and refine the process.** The community begins to implement the strategy informed by their learning and research. Through authentic conversations and feedback, the strategy is refined.
6. **Share outcomes, re-evaluate and determine a new focus.** Members of the learning community determine whether the strategy was successful, if more research or learning is needed, or if the course of action is no longer a priority.



What does this all mean?

Continuing education is essential to the legal profession, encouraging growth among members and advocating best practice. For the young lawyer from Toronto, a Professional Learning Community may have offered an alternative and perhaps less threatening educational opportunity and a solution for her concerns about the “science” component of criminal law. Professional Learning Communities engage diverse learners and promote a proactive and focused team approach to challenge the profession.

This learning model has positively changed the way educators, worldwide, have supported student outcomes. Creating or becoming a member of a PLC can be an enriching experience that improves not only your personal practice, but also the legal profession as a whole. Perhaps this data-driven, solution-based learning model can be adapted to enhance and enrich the practices of legal professionals as well.



More to Explore:

Garrett, K. (2010). Professional learning communities allow a transformational culture to take root. *The Education Digest*, 76(2), 4-9.

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Figure 1 – Steps in creating and participating in a Professional Learning Community.

Susan Reschny has been a professional educator for 30 years. She is currently completing her Doctoral Dissertation in Curriculum Studies at the University of Saskatchewan. Susan continues to work with both adolescent and adult learners. As co-founder of Industrial Training & Design in 1995, Susan has led the company in its development of custom educational content for a variety of business sectors, professional organizations, vocational programs, and government agencies.

An Introduction to Roadside Testers

There have been significant advances in roadside alcohol screening technology over the last twenty years. New fuel cell devices offer an affordable and convenient way for officers at the scene to quickly determine a driver's Breath Alcohol Concentration.

This article will introduce you to the general operation of roadside testers to provide an overview of what they are, how they are used, and what to look for...



Introduction and Overview

Typically, the training program for police officers in the use of roadside screening devices is between 2 - 8-hours in duration. Although the instruments are generally fairly easy to use, they are by no means fool proof (*because fools are often ingenious.*) Because of the lesser degree of training of roadside testers and the need to continually calibrate the instruments themselves, most jurisdiction only allow them to be used as preliminary ethanol screening devices.

In some jurisdictions in the United States, BrAC readings generated by these devices are considered evidentiary results that may result in criminal prosecution. The units must be able to print out the results, and have a timing circuitry that locks out testing during a deprivation and observation period.

Most screening devices are small, relatively inexpensive, and fairly easy to operate. They function on battery power, and are calibrated according to the policy of the local governing policies. They don't receive calibration checks during breath sampling, and as a result, the tests are conducted fairly quickly.

The units are ready for use almost immediately following power-up. The start up sequence for most modern police roadside testers are within a minute of pressing the power-on button. A sterile disposable mouthpiece is placed on the unit, appropriate directions given to the test subject, and a sample obtained. The reading is then displayed within a few seconds. A decision can then be made whether or not to release the motorist, suspend the license, or proceed with a criminal demand for an evidentiary sample.

Most instruments give an indication of the Breath Alcohol Concentration (BrAC) of the subject. This may be provided in numerical form, or displayed in the following manner:

Light Indicator	Result	Reading - Range
● Green	Pass	0 - Suspension threshold
● Amber	Warn	Suspension - legal limit
● Red	Fail	Exceeding legal limit

Table 1 - Non-numerical indicator lights of typical roadside testers

These ranges are subject to the manufacturer's programming per the direction the jurisdiction purchasing the device.

The devices can also be set up to provide a digital readout of BrAC up to a certain range - typically the suspension threshold. This is useful in quantifying amounts for drivers holding restricted or probationary licenses.

Once the Warn light is indicated, a driving suspension is issued, and the subject is released. If the Fail light indicates, then appropriate detention occurs for the purposes of obtaining evidentiary breath samples, and a trip is made to the detachment office or police station. In California, the same unit may be used to obtain the evidentiary samples once the deprivation and observation period has been completed.

Operating Principles

Most modern hand-held screening devices operate using fuel cells that contain a pair of platinum electrodes. From a chemical point of view, the alcohol introduced into the fuel cell is converted to acetic acid, producing a fixed number of free electrons per molecule of alcohol in the process. Therefore, when a breath sample is introduced onto the platinum electrodes, a small electrical current is generated. The current generated is directly proportional to the amount of ethanol in the sample. The greater the concentration of ethanol, the greater the amount of current generated. *This is covered in greater detail in the article on fuel cells, in this issue.*

From the fuel cell sensor, the current is fed to an electronic amplification system, and from there to a digital display.

The unit must receive a sample with sufficient pressure to activate a pre-set pressure transducer. This pressure switch, or *breath pressure flow sensor*, is in place to ensure that the subject is blowing *hard* enough to ensure a sample of deep lung alveolar air is obtained. Once the pressure switch has been activated, a timing circuit is engaged that ensures the subject has blown *long* enough to obtain that sample of deep lung air.



So, in general, two conditions must exist: The subject must *blow hard enough* to activate the pressure switch, and *blow long enough* for the full duration of the sample cycle.

Figure 1 – Providing a sample into an Intoxilyzer S-D5

If the subject tapers their exhalation in their delivery of air, the pressure switch will reset itself, and the test will abort.

If the subject fails to blow sufficiently for the length of time required (typically about 5 seconds), the instrument will again abort the test.

It should be noted that the officer could override this test requirement. If, in the opinion of the operator, the subject has provided a full expiration, and is presently delivering deep-lung air, the operator may capture the air sample prior to the timing sequence being completed.

Some very diminutive people have difficulty in providing a sustained expiration for the full 5 seconds, but have reached taper and are therefore providing deep lung air. Some patients, who suffer from *Chronic Obstructive Pulmonary Disorder (COPD)*, or *Asthma*, are also unable to blow long enough to provide a full sample. *This will be addressed in greater detail in further articles.*

If no ethanol is present in the subject's expiration, the unit is available for an immediate re-test, as the fuel cell is already at zero voltage. Unless the BrAC obtained is very high, the unit should be ready to clear itself of residual ethanol on the fuel sensor, and analyze a second sample within a minute or two, depending upon the previous BrAC.

Some roadside testers are further insulated from Radio Frequency Interference (RFI). Some have no such interference insulation, and as such, operators are instructed to make sure no radio transmitters or cell phones are in the immediate vicinity of the instrument during testing.

The Breath Sampling System

When the subject provides a sample through the disposable mouthpiece, the flow rate is monitored using the breath pressure flow sensor. The pressure output of the donor is compared to their exhalation time by a micro-controller which calculates the volume of air expired. The pressure sensor used in most modern portable breath testers is a solid-state device that is chosen based on its accuracy, reliability and stability under a variety of operational conditions.

Once the donor has blown *hard* enough to activate the breath pressure flow sensor, and *long* enough for the micro-controller to assume deep-lung air is being delivered, the micro-controller activates a solenoid in the sampling system. This solenoid draws in a fixed volume of sample air (our only other variable) from the mouthpiece and passes it directly over the fuel cell. The volume of air is typically about 1 millilitre. *This is smaller than a cube of sugar.*

It should be noted that the minimum sampling conditions are factory-defined, and can only be written into the instrument's memory by someone who has access to the necessary software.

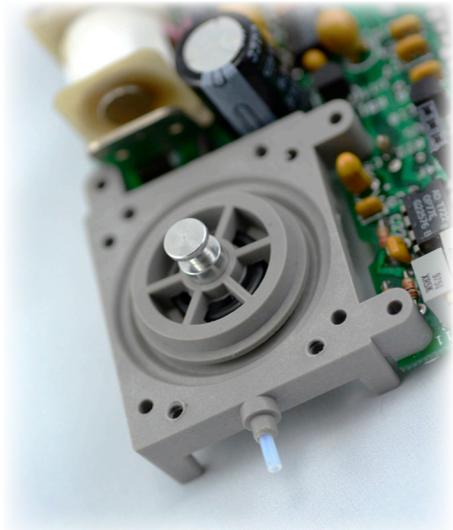


Figure 2 - Visible here is the sample chamber. Note the small tube leading into the chamber, and the solenoid (above left) that activates the pump

On some hand held units, like the Intoxilyzer S-D2, the micro-controller does not activate a solenoid automatically, but indicates by a light that the operator may capture the sample manually. A button is pushed, and a known-volume sample is captured and analyzed.

Officers are taught to capture the sample of air at the point of taper, or when indicated to capture by the light. Once the subject begins to taper off their exhalation, it is assumed that deep lung air is being obtained. The sample is captured and subsequently analyzed

for the presence of ethanol. For the most part, the five seconds of exhalation seems sufficient to capture a deep lung sample.

Units such as the Intoxilyzer Model S-D5, Intoxilyzer Model 400, and the Intoximeter RBT and Alco-Sensor FST utilize an algorithm in the micro-processor to determine when deep lung air is being obtained. Lighter exhalation may require longer duration sampling, while harder expiration may see a sample captured sooner.

Some operators prefer to have the subject exhale fully, and to capture the sample manually. They can then ensure that they are capturing a full exhalation. Big strapping farm lads, athletes, swimmers, and recreational runners should be capable of providing a 10-15 second exhalation with relative ease. In these cases, a five second sample may not produce the necessary full-exhalation.

Disposable Mouthpieces

Different instruments use different size mouthpieces, which are not typically interchangeable. In general, they are designed to offer minimal resistance to breath flow, while generating the small positive pressure necessary at the breath sampling port for a sample capture.

The positive-pressure effect in many breath testers is achieved by making the exhaust side of the mouthpiece a slightly narrower diameter than the donor side. It is essential that the donors are offered the correct side when delivering a sample. If the donor blows through the exhaust end, no positive pressure will be developed, and the pressure transducer and timer circuitry will not be activated. The donor may appear to be blowing sufficiently but the instrument will indicate that the subject is not providing a suitable sample. Appropriate training and operator competence should again ensure that the correct mouthpiece end is being used.



Figure 3 - The lipped "blowing-end" of the mouthpiece on the left, and the restricted orifice of the other end, on the right.

It is also essential that a new mouthpiece be used for each breath test. Condensation from the exhaled breath can form on the inside of the mouthpiece and cross-contaminate subsequently obtained samples. Health concerns also make it imperative that only a new sealed mouthpiece is used for each donor.

Although more expensive mouthpieces, as used with the Model 5000, 8000, and 9000 are transparent, the mouthpieces used by the Intoxilyzer Model 400 and the Alco-Sensor FST are opaque white or translucent. This makes determining if condensation is present very difficult, and again it is suggest a new mouthpiece is used for each test.

In cases where the subject does not appear to be providing a suitable sample, the operator should make it standard practice to discard the mouthpiece and utilize another sealed one. Mouthpieces should be seized in cases of refusal to prove that they were capable of being blown through.

Very rarely, the mouthpieces have extra flash marks on the plastic castings. Again, this is a deviation from standard condition, but something to keep in mind. I have occasionally seen mouthpieces that had extraneous bits of plastic that made them very difficult, and in a few cases, impossible to blow through. A prudent operator will be able to identify these, and will take the appropriate precautions to ensure the overall results of the testing are not adversely affected.

Obviously, only mouthpieces designed for the specific instrument should be used. They are not always interchangeable.

Roadside Testing

Preliminary Donor Questioning

Qualified roadside screeners are generally instructed to ask the donor subjects when they last ingested anything by mouth, whether alcohol, food, or tobacco products. Remember that some medications contain ethanol. Foods, even “non-alcoholic” foods or beverages may contain trace amounts of ethanol that would render the testing process invalid.

If the subject has consumed anything, most manufacturers of breath alcohol testing instruments recommend a minimum delay in testing of about fifteen minutes before taking a breath sample.

Additionally, even though it is generally considered that a 10-12 minute wait will disperse traces of fresh mouth ethanol, other variables exist. Traces may be present on the subject’s dentures or dental work. Breath sprays, applied at the moment of the vehicle stop, may also contain ethanol. Some gums have soft “squirting” centers. Some cough drops also contain soft cough-medicine type centers.

In practical application, the 15-20 minute waiting period is often done only if the subject has indicated, or the officer has reason to suspect, recent consumption of any substance.

Let’s assume the officer has a “reasonable suspicion of alcohol consumption”, and the appropriate demand has been made. The waiting period of 15-20 minutes or so has been observed from any disclosed consumption, or even observed “burps” by the subject that would also introduce fresh mouth alcohol. We then need to collect a sample suitable for analysis to meet the demand requirements.

Alcohol Screening Using a Roadside Tester

As we have discussed, the instruments are often controlled by an on board micro-processor, and are easy to operate. The analytical functions, including the breath sampling procedure, are completely automated in most devices, and do not require operator input. More importantly, neither the operator nor donor can influence the readings and analysis of the sample. Many units have an on board memory to store the results of the last 150 tests or so, which can be downloaded to provide date, time and result data for statistical analysis. The actual operating software of the instrument is written into non-erasable Read Only Memory, and cannot be modified.

Most units can obtain readings in the 0 - 0.400 grams/100mL range (From no ethanol to levels approaching fatal alcohol toxicity). Some newer units read to 0.650 grams/100mL. *That is incredibly high...*

Although most manufacturers' recommendations are that the units should be checked for calibration monthly, it is expected that the drift of the fuel sensor will be so minimal as to not require calibration more than once every six months. The maximum drift of the fuel sensor should not exceed +/- 0.005 grams/100mL per month.

Instrument Checkout and "Wait" Period

To illustrate how a breath sample is obtained, we will use the Intoxilyzer Model 400 as an example. Most units will operate in a similar fashion. Pressing and releasing the ON-OFF switch turns on the roadside screener. At this point, indicator lights begin to scroll, followed in turn by the individual bar segments on the digital display. Then a beeper activates. These start-up tests are done to indicate to the operator that all digital display, indicator lights and audible notification components are working correctly. Once the breath test sequence has begun, the ON-OFF switch is inhibited, and cannot be turned off.



Figure 4 - The Start sequence on the Intoxilyzer Model 400

At the end of the scrolling display check, the "Wait" light is activated, and the sampling system draws in an air sample. This constitutes an ambient air check. The current time and date are displayed, and the instrument software does an internal check of the fuel cell sensor to purge any residual ethanol from previous samples. As well, if the fuel cell is too cold, the instrument will automatically heat the sensor to the workable temperature range.

The "Wait" light continues to show until the fuel cell is completely purged of residual ethanol and acetic acid, residual amperage, and the minimum operating temperature has been reached. During this readying phase, it is not possible to obtain a breath sample from the subject as the breath sampling system is inhibited.



Figure 5 - The operator should observe the unit during its start up sequence to ensure all indicator lights are working, and no error messages are displayed.

The operator should be observing the instrument throughout this readying phase, to ensure the instrument is functioning correctly, that the indicator digital segments are all working, and that no low-battery indicators or error messages are displayed. *Note that any errors registered by the units themselves will not necessarily nullify their ability to accept a breath sample. Operator caution is required.*

When the appropriate conditions are met, the “Ready” light comes on, also indicated by an audible tone. The unit may or may not display the instrument’s test number, depending upon the setup of the instrument.

As soon as the “Ready” light comes on, the instrument is ready to accept a breath sample from the donor. The operator should use a fresh and sealed mouthpiece and attach it to the instrument in such a way that the operator’s fingers don’t actually touch the mouthpiece end. For Canadian lawyers, case law exists in concerning reasonable grounds for refusal on the basis of lack of hygiene¹.



Figure 6 - After attaching the mouthpiece, the operator can pull the wrapper off the donor-end to expose the fresh mouthpiece.

The operator holds the mouthpiece with the wrapper still around the entire mouthpiece but opened at the *exhaust* end. The wrapped is slowly pulled back to reveal the side arm on the mouthpiece. The side arm is engaged onto the sampling port of the instrument. The mouthpiece snaps into place with a positive lock. It does not matter which way the mouthpiece is oriented on this specific instrument, but it is certainly important on others.

¹ R. v. Pittendreigh (1994), 9 M.V.R. (3d) 236 (Alta. C.A.) – Concern about sanitation of an unwrapped mouthpiece is a reasonable excuse.

The operator should then carefully remove the wrapper from the donor-end, and offer the donor-end to the subject with the appropriate explanations. Often, the wrapper is retained by the operator as a sanitary means of getting the mouthpiece off the instrument and discarded without contacting the now-contaminated mouthpiece itself.

Donor Instructions

Once the demand for a roadside breath sample has been read and understood, the subject must be instructed on how to provide the samples. Most operators are taught to instruct the donor to fill their lungs and exhale through the mouthpiece, making a tight seal with their lips around the blowing end. Donors must be instructed to provide the sample in one continuous exhalation. Starting and stopping resets the timing circuitry.

Operators often instruct people not to touch the instrument during sample, and encourage them with, “*Keep blowing, that’s it, keep blowing, keep blowing, keep blowing*” until the sample is captured. Once the sample is captured, they then tell them that they can stop blowing. This helps ensure that the subject does not “suck back” at the end of the sampling phase. However, if the instrument detects a loss of pressure, the tone will stop and the test will be aborted. If negative pressure is detected at any time during the test, the test sequence is again aborted.

The subjects should fill their lungs and blow through the lipped wide end of the mouthpiece. It is not necessary to inhale to the point that the lungs are bursting, and it is not necessary to blow hard enough to inflate a tractor tire - just a nice steady exhalation. Sometimes, subjects are over-eager to provide a sample, and blow so hard and so fast that they cannot sustain the necessary five-second time. The operator should then provide a little more instruction to, “*Blow not quite as hard but a little longer*”, and repeat the testing sequence. A new mouthpiece may be required.

Once the subject starts blowing hard enough to activate the pressure transducer, a “Flow” tone is emitted and the “Flow” light comes on. The ON-OFF switch is inhibited to prevent accidental shutdown of the instrument. The tone continues until the microprocessor has determined that a minimum time has elapsed and the pressure was maintained for a deep lung air sample to be obtained. The sampling pump is activated. This is not just a timing circuit, but a device that measures pressure and Venturi (flow). This determines the minimum breath volume has been exhaled and assists in capturing a required sample of deep-lung alveolar air.

The subject’s breath sample is captured, and the tone stops. A reciprocating piston is automatically activated that draws about a millilitre of breath from the mouthpiece flow assembly directly into the sample chamber and onto the fuel cell for analysis. The sample may also be manually captured by pressing a button while there is sufficient flow .

If the instrument has successfully captured the breath sample, two tones emit, and the instrument begins the analysis phase of operation. In essence, the donor must blow long and hard enough to get the instrument to emit the short double beep to initiate a sample capture.



Figure 7 - The numerical display of the BrAC is displayed after the fuel cell reaches its peak Amperage production.

Once the sample has been successfully captured, the instrument will begin to analyze it for ethanol content. The “Analyzing” and “Wait” lights come on, and everybody holds their breath (*figuratively, not literally*). The longer the sample takes to analyze, the more current is produced, with a higher final reading often obtained. The “Analyzing” light may be on for as much as thirty seconds or more, depending upon the BAC.

Once the “Analyzing” light goes off, the digital display provides a reading in grams/100ml. The digital display on many units is lit for night use.

Some Final Thoughts:

The technology behind fuel cell devices and roadside testers is getting more mature. We know that DUI s are common occurrences. The article in this issue on DUI investigations shows some of the numbers involved. The vast majority of cases I get for review involve both a roadside test and an evidentiary test. You need to understand both technologies - their respective strengths and limitations - in order to address issues in court.

Future articles will discuss the pro’s and con’s of fuel cell devices, focusing on how they are employed daily by police, and what issues need to be examined. What is a Daily Log? What is a Usage Log? What is a Calibration Log? How often do they need Calibration? How do they drift? What happens when fuel cells are spent?



More to Explore:

Harding, P. and Zetl, J. R.; Chapter 7. Methods for Breath Alcohol Testing. *Garriott's Medicolegal Aspects of Alcohol*, 6th Edition; Lawyers & Judges Publishing Company, Tucson, 2015; pages 229 – 252.

“*Intoxilyzer 400 Operating Manual*”, CMI, Incorporated, Owensboro, Kentucky, 1996.

“*Intoxilyzer S-D2 Operator's Manual*”, CMI Incorporated, Owensboro, Kentucky, 1998.

“*Intoxilyzer S-D5 Operator's Manual*”, CMI Incorporated, Owensboro, Kentucky, 2002.

“*Intoximeter Alco-Sensor FST Operator's Manual*”, Intoximeters, Inc., St. Louis, Missouri, June 2007.

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TECH REVIEW

Tablet Roundup 2015



If you're in the market for a new tablet, you know that there are dozens out there to choose from. Despite all the hype, tablets are a long way from replacing your laptop. But, they are a convenient way to check your e-mail, surf the web, and catch the latest release on Netflix.

Tablets shine as e-readers, and are quickly replacing traditional paper books, magazines, and textbooks in the publishing market.

Counterpoint will be published in the latest electronic EPUB 3.0 format, so we thought we would include some information on the latest tablets on the market.

Designing for a new technology

Designing Counterpoint has been a bit of a challenge due to the ever changing tablet and e-reader market. Newer tablets use higher screen resolutions, and while some people prefer horizontal (or landscape) orientation others prefer their devices held vertically (or portrait).

We've decided to format the journal to use a higher screen resolution that offers superior cross-platform compatibility, and have chosen the 1024 x 768 standard. This should offer the reader an easily readable image, rich with beautiful full color images and less eyestrain, while still looking great on both medium and high-resolution displays.

But, times will change, and we will format Counterpoint for high resolution retina displays. The move to 2048 x 1536 is one the way...

As for orientation, we've chosen the traditional landscape format as it means readers using laptops or computer displays can enlarge the image easily to fill the screen.

Older tablet users may want to consider one of the newer high-resolution models to experience the bright graphics, with easy to read text.

While we are at it, the font and text size have been chosen for ease of readability across platforms. Most people prefer a two or even three column layout, with lots of embedded graphics. If you have any thoughts, please feel free to share...

The four tablets listed here are by no means a complete list of the top sellers of 2015. We've included them on this list because they offer, as a group, the lightest, thinnest models, with big high-resolution screens, long battery life, and top critic review scores.

Editor's Choice

Apple iPad Air 2

A review of many online computer journal's ratings of tablets typically finds the iPad Air 2 as the *Tablet of Choice*, even among the non-Mac lovers. Lighter, faster and with a gorgeous high-density pixel display, the iPad Air 2 is thinner (6.1mm) and lighter (437 grams) than the original iPad. Graphics are sharp and fast on this tablet. The unit sports one of the longest battery lives of comparable tablets. Also, the built in front facing 1.2MP camera is faster, making fact-to-face online chats easier. The rear camera is a high-resolution 8MP still / 1080p HD video hybrid.

The anti-reflective bold color and high-contrast display is easy on the eyes with a full resolution of 2048 x 1536 pixels, and includes a touch ID sensor so you can unlock the tablet, and make online purchases with a single finger press. The touch display is responsive and easy to use. The rear facing speaker sound is perhaps a little tinny. What really sets the iPad apart from the other tablets are the numerous apps available.

Pricing starts at \$499 - \$829 USD (\$549 – \$899 CDN) depending upon the capacity and cellular options.



Samsung Galaxy Tab S 10.5



The 10.5 designation in its name refers to the screen size diagonally – 10.5 inches. Only 6.6 mm thick, this tablet is slim and light at only 295 grams. The Tab S 10.5 boasts a very vibrant and colorful 2560 x 1600 *Active Matrix Organic Light Emitting Diode* (AMOLED) display. The Galaxy has stereo speakers with fairly impressive audio, even though it may be a little shy on the bass. The unit unlocks via the fingerprint scanner.

As with most of the tablets in this roundup, the Samsung Tab S has a front facing 2.1 MP camera, and a rear facing 8MP camera with full HD 1080p video recording. The memory is expandable to 128 GB by the use of Micro SD cards. Samsung claims the battery can last up to 9 hours.

Samsung's suggested prices list between \$400 - \$650 USD (\$460 - \$720 CDN) depending upon the configuration of the unit.

Microsoft Surface Pro 3



Often rated the best of both the *2-in-1 Tablets*, and *Windows OS Tablets*, the Microsoft Surface Pro 3 is a serious piece of computing machinery. Doubling both as a tablet and Windows laptop, the Surface Pro 3 has a bright and colorful display and an attractive design. Microsoft has directly compared the Surface Pro 3 to BOTH the iPad Air and MacBook Air. Because it is a full-fledged laptop as well, it will run serious applications, not just the stripped down versions offered for tablets. *It will run the new Windows 10 which is also getting great reviews in beta format testing.*

The display measures 12 inches diagonally, with a 2160 x 1440 pixel output, and allows the use of a stylus input, or touch responses including pinching and zooming. The sound output is loud enough to fill a living room, and is rich and full textured. The tablet has a long battery life, although shorter than the iPad Air 2. Due to its laptop-based design, the Surface Pro 3 weighs a whopping 800 grams before you add the optional detachable keyboard.

One drawback is its hefty price tag, from \$ 799 - \$1799 USD (\$950 - \$2350 CDN) depending upon the configuration and optional keyboard.

Dell Venue 10 7000



Just released is the Dell Venue 10 7000, replacing the smaller Dell Venue 8 7000, which was often found at the top of Editor's Choice lists as the best Android tablet. Incredibly thin at only 6mm, and with a vibrant 2560 x 1600 pixel *Organic Light Emitting Diode* (OLED) display, the Dell Venue 10 7000 has speedy performance, reasonable battery life and an attractive modular design.

The tablet has a unique barrel-edge grip that makes reading in portrait orientation natural and comfortable. An optional Bluetooth keyboard snaps onto the titanium barrel portion of the tablet with strong field magnets. This is a premium tablet with an anodized gunmetal grey aluminum chassis, while weighing almost 600 grams. The front mounted stereo speakers are loud enough to fill a room built into the titanium barrel. The tablet also boasts a pair of 2MP stereoscopic rear-facing cameras, along with the regular 8MP/1080p rear camera.

The Dell Venue 10 7000 operates on the Android operating system. MSRP starting at \$499 USD (\$599 CDN).

Tablet Roundup 2015

Features at a glance

	Apple iPad Air 2	Dell Venue 10 7000	Microsoft Surface Pro 3	Samsung Galaxy Tab 10.5
Resolution	2048 x 1536	2560 x 1600	2160 x 1440	2560 x 1600
Display	9.7" Retina LCD 4:3 Aspect	10.5" OLED 16:9 Aspect	12" 3:2 Aspect	10.5" AMOLED 16:9 Aspect
Dimensions	9.4 x 6.6 x .24 inches 240 x 170 x 6.1 mm	9.6 x 7.7 x .24 inches 243 x 195 x 6.2 mm	11.5 x 7.9 x .36 inches 291 x 201 x 9.1 mm	9.7 x 7 x .26 inches 246 x 178 x 6.6 mm
Weight	437 g (0.96 lbs.) Anodized Aluminum	597 g (1.32 lbs.) Anodized Aluminum Titanium barrel	800 g (1.76 lbs.) Polished Magnesium	295 g (0.65 lbs.) Plastic
Cameras	Front: 1.2MP Rear: 8 MP /1080p	Front: 2MP Rear: 2MP 3D Stereo & 8MP / 1080p	Front: 5MP Rear: 5MP / 1080p	Front: 2.1MP Rear: 8MP / 1080p
Speakers	Rear Facing Stereo	Front Facing Stereo	Stereo with Dolby	Stereo – edge mount
Operating System	Apple iOS 8	Android 5.0 Lollipop	Windows 8.1 Pro	Android 4.4 KitKat
Memory	2GB RAM 16-128 GB Storage	2GB RAM 16-32 GB Storage (Up to 512GB with Micro SD Slot)	4GB RAM with 64-128GB Storage, or/ 8GB RAM with 256-512 GB Storage	3GB RAM 16GB Storage (Up to 128GB with Micro SD Slot)
Wireless	802.11 a/b/g/n/ac Bluetooth 4.0	802.11 a/c Bluetooth 4.1	802.11 a/b/g/n/ac Bluetooth 4.0	802.11 a/b/g/n/ac Bluetooth 4.0
Battery Life	Up to 10 hours	Up to 7 hours	Up to 9 hours	Up to 9 hours
Critic Reviews*	8.7 / 10	Too new for review scores	7.9 / 10	8.3 / 10
MSRP	\$550 - \$900	\$500 - \$680	\$800 - \$2350	\$620

* Compiled from multiple online reviews by Engadget.com

Final Thoughts

Thanks very much for taking the time to explore the sample issue of *Counterpoint*. I hope you will subscribe to the journal, and benefit from the great educational material it presents. It is our hope that together we can create an environment for exploration and understanding of some pretty complex scientific and technical issues.

In the Fall 2015 (Volume 1, Issue 1) of *Counterpoint*:

- An overview of immigration issues faced when a person charged with a DUI tries to cross the Canada-US border, from Canadian immigration attorney Marshall Drukarsh
- Factors affecting ethanol absorption in the human body
- A discussion on issues of accuracy, precision, and reliability in breath testing
- An introduction to the new Intoxilyzer® 9000 from Texas criminal attorney Mark Thiessen
- A look at the new technology in police body cams
- A discussion on the logic and history of the SFST developments by researcher Dary Fiorentino, Ph. D.
- A look at effective electronic-learning strategies using presentation programs
- An overview of the top laptop projectors for fall 2015

Until then, enjoy your summer. I look forward to receiving your comments on this sample issue. *Take care...*

Jan Semenoff

Editor-in-Chief

A call for information:

Please forward any information on the following:

Announcements of upcoming:

- Seminars & conferences
- Training programs or packages
- New book releases
- New product reviews
- Services important for our readers

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