TECH Review : BACtrack Mobile

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Photo courtesy of BACtrack - © 2016 KHN Solutions Inc.

The BACtrack Mobile Smartphone Breathalyzer

A New and Emerging Market

Over the last ten years I've tested a variety of novelty mini "key-chain" breath alcohol testers. You may have seen these things in the checkout at Wal-Mart, or advertised online on Amazon or eBay. I've spent individually anywhere from $15 to more than $275 on these devices. Frankly, most are total junk, and not worth the time to write about. *Caveat emptor…*

The concern with these devices, obviously, is that they will provide *false-negative* results – that is to say, they will tell drivers testing themselves that they are "good to go" when they should not be behind the wheel. These *false-negative* results will indicate a driver's measured Breath Alcohol Concentration (BrAC) and therefore their Blood Alcohol Concentration (BAC) is under some set statutory limit – either defining Impairment, or for an imposed suspension threshold.

Fuel Cell Sensors vs Semi-Conductors

As such, accuracy of the devices becomes paramount. To be fair, most of the novelty breath test devices use older semi-conductor technology. Modern, professional-grade police hand-held units use *Fuel Cells* to measure a BrAC. We've talked about fuel cells in the past (See Counterpoint's Free Introductory Issue articles: "*Fuel Cell Basics*" and "*An Overview of Roadside Testing Devices*" for a review on fuel cell technology).

Fuel cells work by converting a source of energy (ethanol, in this case) into an electrical current. More ethanol in the sample provided simply yields more electrical current production, thereby providing a means of measuring the ethanol in the breath sample.

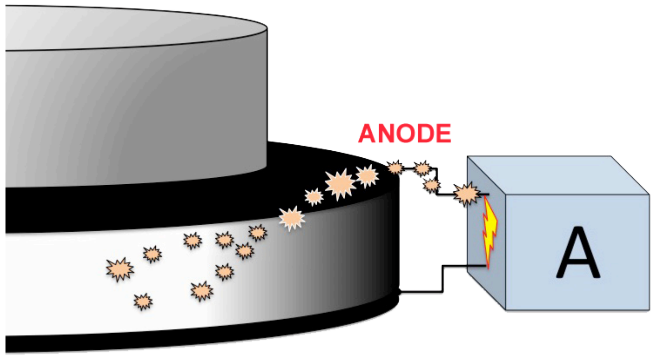


Figure 1 - A fuel cell converts ethanol into an electric current

Older semi-conductor devices, used in early police breath test hand held and roadside units, utilized a *Taguchi*[1] *Metal Oxide Semiconductor*. Rather than produce electrical energy, as in a fuel cell, semi-conductor devices control the flow of electrical current under some conditions, but not others. Specifically, they impede or reduce the current flow when ethanol is introduced into the semiconductor cell. More ethanol simply creates more electrical resistance. The flow of energy is reduced, and it is this reduction that is used to measure the ethanol in the breath sample.

So, why did we go from semiconductors to fuel cells? They seem to be able to both measure a quantity of ethanol in a breath sample?

Semiconductors have major disadvantages. They are quite prone to electrical drift, meaning that the calibration of the devices was all over the place, resulting in reduced **precision**. They are more dependent upon the ambient temperature – far more so than fuel cells, resulting in reduced **accuracy**. The semiconductor module actually heats up the gas sample as an electrical vapor detector. This was hard on the on board batteries for a breath alcohol testing device.

1 Metal Oxide Semiconductors are often referred to as Taguchi Semiconductors, as patented by Naoyoshi Taguchi in 1969. He devised a method more making a gas-sensing detection element utilizing metal oxide semiconductor technology, changing the sensor technology of the day from chemical to electrical.

Additionally, the semiconductor modules would react with a variety of Volatile Organic Compounds (VOCs), resulting in reduced **specificity** to ethanol, and subject to false positives due to chemical exposure, or production of ketones as with a diabetic or fasting test subject.

As with many other electronic or electrical components, fuel cell prices have dropped over the years. With the introduction of cheap fuel cells, and cheaper microprocessor chips for on board technology, the prices of hand held breath testing devices are also dropping. Units that were $1200-1400 dollars in the early 1990s are now under $500 today. Lithium ion batteries also provide more power, at a lower weight and size bulk, and cost, than before. The technology for hand held units is improving.

The BACtrack Mobile

Enter the **BACtrack® Mobile**. This small, palm size device, utilizes a fuel cell and Bluetooth connectivity to sync with your smartphone, creating a system that automates the breath testing process. The manufacturer, *KHN Solutions, Inc. of San Francisco*, claim "police-grade accuracy."

So, we decided to put that claim to the test, challenging the little unit to perform against its police counterparts, all of which are on the **DOT** *Conforming Products List.*

Figure 2 - The BACtrack Mobile next to an iPhone.
Photo courtesy KHN Solutions, Inc.

Initial Setup

Connecting the BACtrack to the smartphone was about as painless as it gets. I downloaded the BACtrack App (version 2.3.9) from iTunes for free, and quickly paired the device with my iPhone 6. It is also available as an Android compatible device, though I did not test that software in this review. There were no issues with either the download or pairing.

After creating an account[2], I was able to set my units in the Settings Menu into my preferred milligrams per 100 millilitres of blood. US users can also use the familiar grams per 100 mL measurement. European users will also be able to pick from permille and permille by mass. I don't know if switching to a European standard also changes the Blood to Breath sampling ratio (the BrAC:BAC ratio is 2100:1 in North America, but typically 2300:1 in Europe). *See Counterpoint Volume, Issue 2 for a discussion on Blood to Breath Ratios.*

The user interface couldn't be any easier. When you first touch the BACtrack icon on your smartphone screen, it automatically pairs with the device via Bluetooth. Diagrams show you how to turn on your specific model for pairing. Once paired, the device glows blue through the transparent sample chamber, and a big button labeled "BAC test" appears on the smartphone screen. Touching the icon on your phone's screen starts the breath test sequence.

Figure 3 - Starting the application on your smartphone begins the prompt sequence for the BACtrack Mobile. *Just follow the directions...*

2 The account also had a lot of user information required, more so than perhaps I am comfortable to provide. I haven't had an opportunity to go through the Privacy Policy yet, but there is an option to NOT store my data online, and to share the readings anonymously.

First, it warms up the device, then prompts the user to take a deep breath.

Next, the “Blow now!” prompt appears. As a sample is provided, a diagram of a segmented circle advances to the end of the sample. The device is tricky. It captures the sample at the end of the expiration, but before the circle is complete, helping to ensure that the sample pressure is maintained for a more accurate reading. The unit then analyzes the sample and displays the BrAC on the smartphone screen.

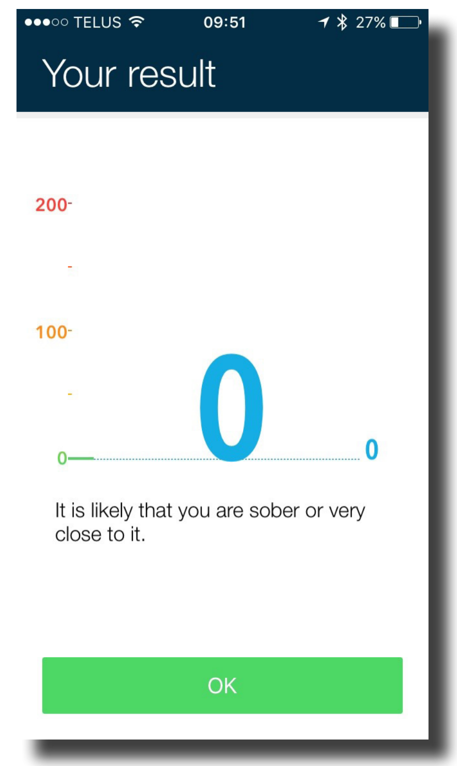
Figure 4 - The display screen provides instructions on how to provide a sample suitable for analysis.

I have an initial concern. The device collects the breath sample perhaps a little too quickly. Most police hand held units (and all that we used for comparative testing) require a full five-second exhalation before capturing a breath sample. The BACtrack required four seconds of exhalation before automatically capturing the breath sample. Whether you accept the “five-second deep lung air sample” criteria or not is perhaps best left for another article, but it may explain the minor differences in readings we obtained.

Also, a breath sample may be collected with a pressure that is far below that typically required by a police grade tester. Most modern units require a fairly significant pressure of forced exhalation to activate the pressure transducer over the five-second exhalation. A minimum breath sample volume of about 600 mL is required. The BACtrack accepts a very light exhalation force, with again, only a four second sample.

I’d like to be able to take a BACtrack Mobile apart and measure the size of the sample chamber. Most police units have an air sample chamber that captures about 1 millilitre of breath. I have a sneaking suspicion that this sample chamber is a little smaller. A more thorough review of the device would yield some numbers.

Finally, the software gives you some indication of how long it will be before you are sober. I don’t know the elimination rate used to make that calculation, and neither the instructions nor any online information provide this critical rate used by the algorithm to calculate when you are “sober”.



In short, the performance characteristics, and the very friendly user interface on the smartphone App make the BACtrack very easy to use. The user is prompted at each stage of the test process, with a great graphical and picture prompt interface.

Calibration

The unit can be returned to BACtrack and calibrated at a cost of USD $24.99. They recommend a calibration “at least every 12 months”, and more often if used frequently. This is very good advice.

Figure 5 - The results of your breath sample are displayed. You are also able to look at a graphical display of a series of results over time, with the unit giving an indication of when you will be able to drive.

The Accuracy of the Device

Comparing this unit to a $9000 infrared or electrochemical / IR hybrid seems inappropriate. Instead, we decided to compare the unit to well-known and long-used police and Industrial/DOT hand held units. Specifically, we compared the BACtrack Mobile to the Intoximeter FST, and the older Intoxilyzer Models 400 and SD-2. These three units are listed on the US DOT Conforming Products List as evidentiary breath alcohol testing devices.

Figure 6 - A lineup of the usual suspects: The Intoximeter FST; Intoxilyzer 400, and Intoxilyzer S-D2 (left to right)

Methodology

I just wanted a quick feel to compare the readings between the DOT units and the BACtrack Mobile. This was for quick review purposes, and is not intended to imply an accurate scientific test or evaluation. Only one test subject was employed (me!), over a single episode of consumption.

The DOT units were calibrated prior to testing, and again after testing, with any change in calibrated used to calculate corrected BrAC values. The correction needed on the older Intoxilyzer units was extreme, indicating the fuel cells are nearing the end of their serviceable life.[3]

I consumed five standard drinks between 5 and 7 PM one evening. A light meal was consumed concurrently. I finished my last sip of red wine at precisely 7PM (1900 hrs), and consumed nothing further by mouth at all over the two-hour testing period. A 15-minute deprivation period was performed. No fresh mouth alcohol conditions occurred (burps, belches or regurgitation). Every five minutes, I would provide a sample into each device, in the same order, at about 1 minute intervals. Testing continued for two hours. The results of each breath test from each device were logged. In total, 100 breath samples were provided. No errors occurred from the BACtrack device, or the Intoximeter FST. The data indicates, however, aging fuel cells in the older Intoxilyzer units, as scene in Figure 7:

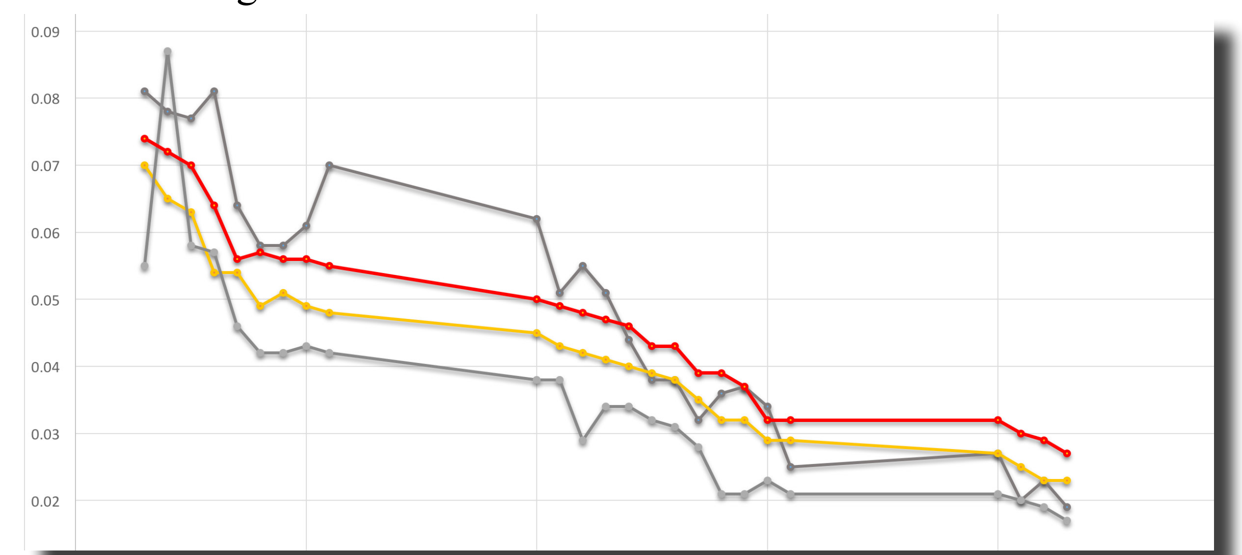


Figure 7 - The performance of the older devices (gray lines) showed their aging fuel cells were failing. Note the erratic readings.

3 It is difficult, if not impossible, to obtain *evidentiary* breath testing units for analysis by private individuals. The manufacturers are reluctant, or outright refuse, to sell units to persons who have any association with criminal defense or civil lawyers, and defense organizations. As such, independent, third-party testing of these devices is extremely limited, as the units have a finite shelf life, and cannot be easily serviced by other than factory service providers.

Failing Fuel Cells

Notice the gray lines in Figure 7. The "bouncing around" of the readings of the older Intoxilyzer units is indicative of fuel cells. Although they follow the general pattern of elimination over the two hour testing period, there are a number of anomalous readings obtained from these older instruments. The SD-2 particularly gave a number of readings above .08 at odds with the other readings. The Intoxilyzer 400 gave a reading that was probably too LOW to begin with (right at 1915 hours) then followed up with a spiked reading above .08 five-minutes later.

> *I should note that I did NOT provide samples in the sequence of Intoxilyzer SD-2, BACtrack, Intoximeter FST and finally the Intoxilyzer 400.* Had I done so, and obtained these results, we might wonder if the overall higher and lower responses of one device over another were due to the minimal one-minute interval between samples. Perhaps not enough time had elapsed for equilibrium between the alcohol in my blood and lungs to stabilize? In fact, I took samples in the order of Intoxilyzer SD-2, then the Intoxilyzer 400, followed by the Intoximeter FST, and finally the BACtrack Mobile. If blood to breath equalization were an issue, the BACtrack Mobile should provide a consistently LOW result, but instead, it has a higher reading. This is NOT the result of a high calibration, either, as we were to find out.

It is these anomalous readings that indicate a fuel cell has nearly depleted its chemical component. Both these units are more than 15 years old, both were purchased brand new from Intoxilyzer, and most importantly, both have received little use – the occasional training program or seminar, or testing for some clinical purpose. The fuel cells have not received the typical use of a police hand held unit. Many of those older police units are still in use as well.

One can spot a failing fuel cell by looking at the calibration records for the device. When the calibration starts to drift high and low, sometimes to extremes, or as is often the case, drifting low (as indicated by the Intoxilyzer 400 in **Figure 7** – the lowest consistent readings obtained were from that unit) with the occasional high spike, the unit is failing and should be replaced. Replacing the fuel cell itself is an answer, but that will probably cost more than half of the price of a new unit altogether, so often they are used until they can no longer be calibrated, and are discarded.

Unfortunately, the last readings obtained for the months before the unit is discarded are wholly unreliable. Given that these units can often be used at roadside as *evidentiary* units, as in California, one must wonder about the possibility of inappropriate readings being presented before the courts.

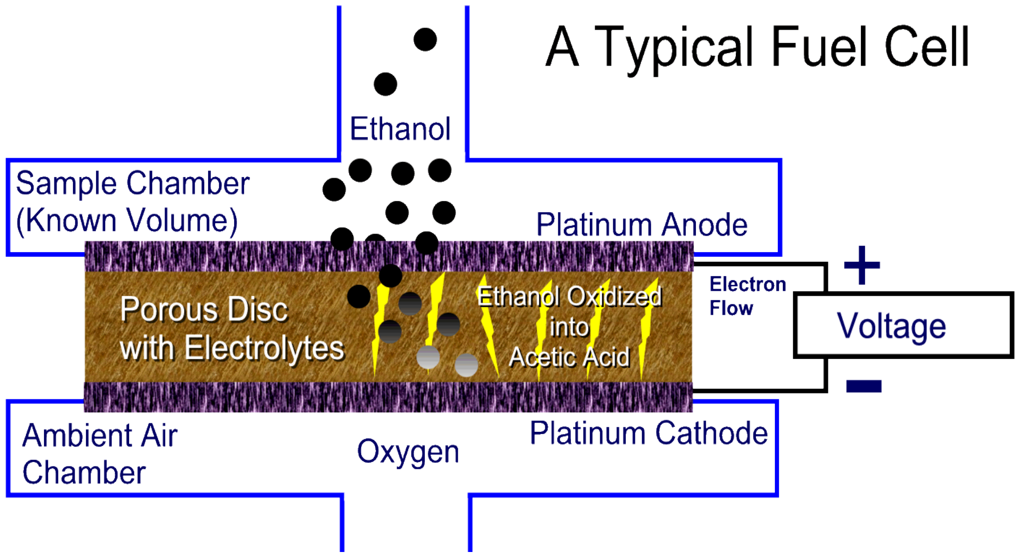


Figure 8 - All fuel cells will eventually fail. They contain an acidic solution that converts the ethanol to acetic acid. Each time the fuel cell device is used, a little more of the acid is reduced, until such point that the cell is unable to be properly calibrated. Fluctuations in readings is typical of a fuel cell nearing the end of its serviceable life.

Analysis of Results

In any event, due to the apparently inappropriate readings obtained with the older units, let's concentrate on comparing the BACtrack Mobile to the Intoximeter FST. I've eliminated the results of the older Intoxilyzer units in **Figure 9**:

Figure 9 - Comparison of the Intoximeter FST (Red) with the BACtrack Mobile (blue). The overall downward trend is shown with the dashed green line.

Examining the results, one can't help at notice the overall similarity with the results between the Intoximeter FST (red) and the BACtrack Mobile (blue). Regardless of differences in sample provision criteria, the results are surprisingly congruent with the DOT approved unit.

An indication of Fresh Mouth Alcohol ?

Notice one more important aspect of the graph, and compare this component with **Figure 7**. The sharp downward slope in the first twenty minutes or so of readings is very much the same among all four units. It is only until about 1935 that the slope flattens out, continuing in the same elimination rate until the end of testing. These first 20 minutes of readings are probably the result of fresh mouth alcohol contamination.

If my elimination trend is extrapolated, as shown in the dashed green line, my peak BrAC at the beginning of testing should have been around 0.055 grams. Instead, both units showed apparently inflated readings of 0.065 (BACtrack Mobile) and 0.075 (Intoximeter FST) respectively. Note that I performed a 15-minute deprivation period prior to providing samples. The data clearly indicates that, for some reason, I had mouth alcohol contamination that lasted for about 35 minutes from my last sip of red wine.

First, this shows the limitations of relying upon readings that do not have the ability to indicate that mouth alcohol contamination is present.

More importantly, it seems to indicate that mouth alcohol contamination was present, for some reason, for more than 35 minutes (1945 hrs) following my point of last consumption (1900 hrs). Many forensic criminalists and toxicologists have opined that ALL mouth alcohol contamination disappears after 20 minutes, maximum. This data, I respectfully suggest, indicates otherwise.

Correction Factors - Fuel Cell Failures

After the units had rested overnight, I performed a series of calibration checks on each unit. A Guth 34C simulator with .100 Calwave ethyl alcohol standard solution was warmed to 34.0°C. Five measurements were taken from each device, and the average of the readings was obtained as follows:

	SD-2		FST		400		BACtrack	
	RAW	CORR	RAW	CORR	RAW	CORR	RAW	CORR
.10 solution	.060	.076	.098	.092	.067	.090	.089	.100
	.077	.098	.108	.102	.065	.087	.088	.099
	.082	.104	.108	.102	.069	.092	.088	.099
	.080	.101	.110	.103	.065	.087	.087	.097
	.068	.086	.107	.103	.062	.083	.086	.096
Average	.073	.093	.106	.100	.066	.088	.088	.098
Correction	+27%		-6%		+34%		+12%	

Figure 10 - The raw data of calibration checks performed

For each unit, the raw calibration checks are shown, in blue, in their respective left-hand column. I tallied those values, showing that the Intoxilyzer SD-2 was reading, overall, about .027 grams low for a .10 gram reading. *Therefore, I would have to correct its reported value by adding 27% to each reading. That is way too much*. Next, the Intoximeter FST indicates that it is reading about 6% high. *I have to subtract 6% from each reading to correct for calibration drift.*

The poor old Intoxilyzer 400's fuel cell is really drifting low. Notice its average calibration check reading at .066 of the expected .100 grams. *I need to add 34% to each reading to correct for the failing fuel cell. This show the end of the fuel cell's life - the calibration factor is too high to be reliable.* Finally, the BACtrack's calibration checks shows it was reading, on average, .088 of the expected .100 grams reading. *I will have to add 12% to each reading to correct for this low initial calibration of the fuel cell.*

I applied the corrections to each calibration check, as shown in the green value in the right hand column for each unit. *Again, let's discard the results of the older Intoxilyzer units.* I think I've finally determined that these specific units are no longer reliable, as discussed: [4]

	FST		BACtrack	
	RAW	CORR	RAW	CORR
.10 solution	.098	.092	.089	.100
	.108	.102	.088	.099
	.108	.102	.088	.099
	.110	.103	.087	.097
	.107	.103	.086	.096
Average	**0.106**	**0.100**	**0.088**	**0.098**
Correction	**-6%**	**0**	**+12%**	**+2%**

Figure 11 - A comparison of the corrected values between the Intoximeter FST and the BACtrack Mobile, showing relative congruency. Compare the corrected green columns for each unit.

The corrected calibration values are, on average, perfect for the Intoximeter FST (**0.100**), and only 2% Low (**0.098**) for the BACtrack Mobile. The results are really very good.[5]

4 I'm ***NOT*** saying generally that the Intoxilyzer 400 or S-D2 units, on whole, are unreliable. I'm saying that, based on the data, MY specific units are old an showing indications of unreliability due to aging fuel cells.

5 One reason I'm applying mathematically corrected readings is that I do not have the software necessary to *calibrate* the BACtrack Mobile device. Recall that there is a vast difference between a simple *calibration check*, which I've passively done here, and an active *calibration*, which actually corrects the value of the device.

Finally, **Figure 12** shows the raw and corrected BrAC values for the testing:

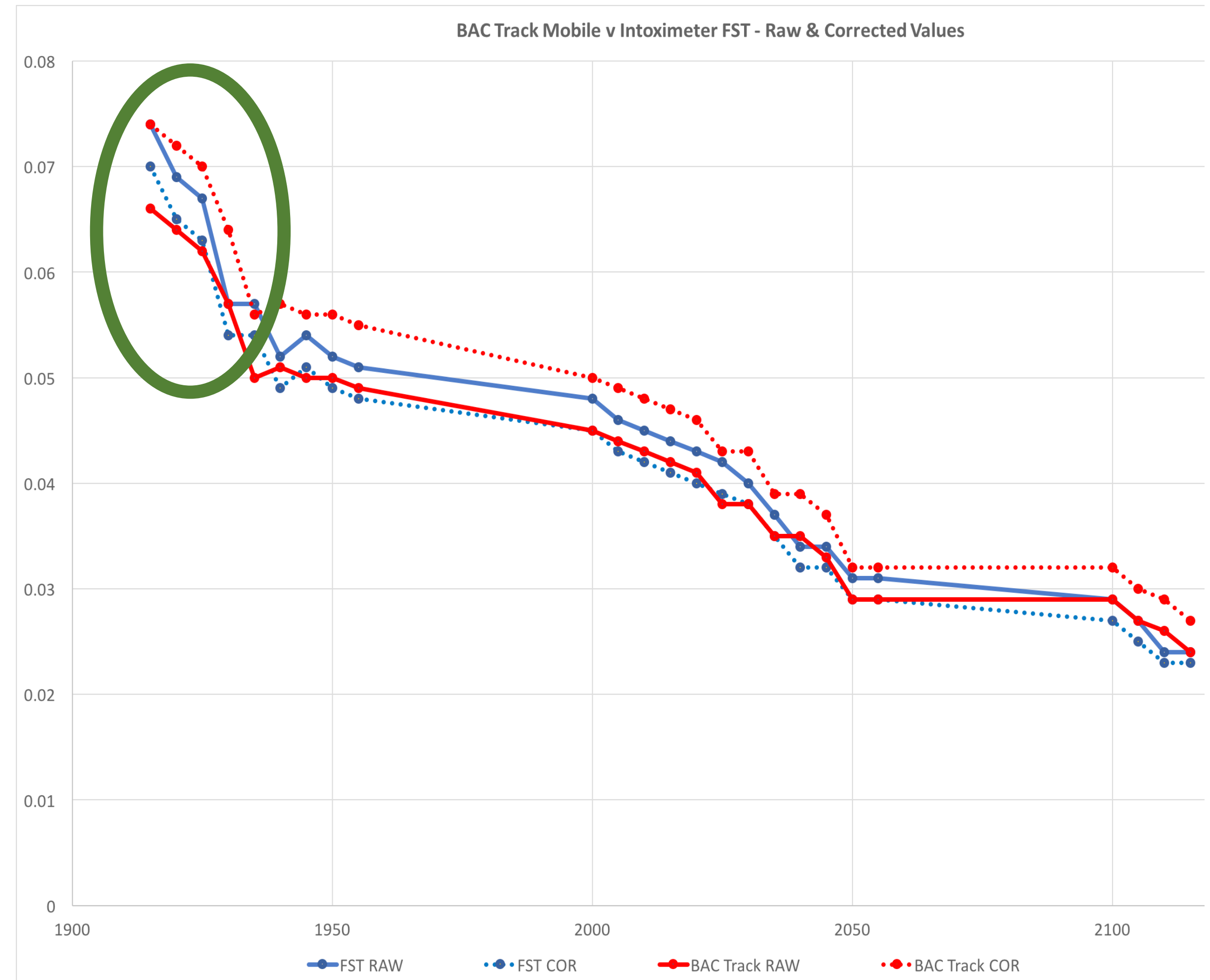


Figure 12 - The corrected values are shown in a dotted line, and the raw values a solid line for each unit.

Again, notice the sharply higher values during the period that fresh mouth alcohol influenced the readings until about 1935 hours, highlighted in the green ellipse. After this mouth alcohol contamination effect is reduced, I have a steady elimination rate of about 0.019 grams per hour.

Both the raw and corrected value readings for the units are very close, certainly within the measurement uncertainty of each unit.

Final Thoughts

Unfortunately, my assessment data set is limited. If I could access a number of BACtrack Mobile devices, I would be able to generate a larger data set, under a variety of conditions, to better determine its overall accuracy, precision and reliability. But, the initial impression is that the BACtrack Mobile appears to provide readings consistent with DOT approved hand held devices.

Is it worth the money to own a BACtrack Mobile? Based on first impressions, I think so. The unit seems to provide results equivalent to the Intoximeter FST, one of the better police screening devices on the market. Personally, I'd like to know my range of readings rather than trying to make an educated guess (*and I'm a court declared expert on the matter, many times over*) as to my blood alcohol concentration.

On the whole, the unit is light and compact, easy to use, and seems to provide accurate and reliable readings. For an evening out, I far prefer to carry the BACtrack Mobile than lugging along a unit like the FST, or the Intoxilyzer S-D5. Keep in mind that the general public has little access to police-grade screening devices, but easy access to something like the BACtrack Mobile.

I've been using breath alcohol testers of one sort or another professionally for almost thirty years. The BACtrack Mobile is easy to use, and with the limited testing I've been able to do, appears accurate. But again, the issue always comes down to one of accuracy, precision and reliability. The BACtrack Mobile seems to score high in all three areas. As with anything, let the buyer beware, but more importantly, don't ever driving while impaired.

Comments? Contact us here: Comments@Counterpoint-Journal.com

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