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Laboratory Testing of Two Prototype In-Vehicle Breath Test Devices

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16. Abstract

This report presents the results of laboratory testing of two recently developed prototype in-vehicle breath test devices. These devices are designed to prevent persons with alcohol on their breath from driving a car. The devices tested were the SOBERLYZER and the ALCOHOL BREATH IGNITION CONTROLLER (A. B. I. C.). In addition to alcohol sensors, these devices have features built into them to check whether the sample being introduced is a true breath sample. The SOBERLYZER has a temperature sensor designed to check whether the sample being introduced is the same temperature as a human breath. The A. B. I. C. has a pressure switch designed to check whether the force activating the system is as strong as a human breath.

The SOBERLYZER distinguished 100% of the time between simulated breath alcohol samples above and below a threshold between 0.015%-0.020% BAC. The actual threshold was about 0.015% BAC below the 0.025% BAC level reported by the manufacturer. The range of temperatures within which the SOBERLYZER allowed us to start a car was much wider (75-100°F) than reported by the manufacturer (89-98°F), and proved relatively easy to satisfy.

The alcohol sensor of the A. B. I. C. distinguished between simulated breath samples above and below a threshold of 0.050% BAC. However, this measured threshold was half the concentration reported by the manufacturer (0.05% vs. 0.10% BAC). Regarding the breath pressure required to activate the A. B. I. C., it proved to be so great that an average person must blow as hard as he/she can to satisfy it.

This research also demonstrated that bogus, substitute breath samples could be introduced into either in-vehicle device to "fool" the system. In the case of the SOBERLYZER, alcohol could also be easily filtered out of breath samples before they were blown into the device to "fool" the system. Strategies that filter alcohol from breath samples could not be tested on the A. B. I. C. because available equipment could not produce enough pressure to activate the A. B. I. C.'s pressure switch.

Only one prototype unit of each device was tested in this research project. Therefore, it is inappropriate to generalize these results to all current and future units. This evaluation is neither an endorsement of, nor an objection to product development in this area. Nevertheless, the findings should be useful to those who are attempting to develop practical in-vehicle breath test devices.

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James F. Frank

Introduction

The concept of using in-vehicle breath testers to prevent persons with alcohol on their breath from driving a car has been entertained for some time. However, versions developed in the early 1970s were too susceptible to circumvention or cheating to be practical (see Snyder, 1984 for a historical overview of developments in this area). Recently, several new in-vehicle breath alcohol testing devices have been developed and may soon be commercially available. These devices include vehicle ignition interlock systems designed to prevent drivers whose breath alcohol concentrations are above some minimum level from starting their car. In addition to alcohol sensors, some devices have additional features built into them to check whether the sample being introduced is a true breath sample. For example, in one case a temperature sensor has also been designed into the device to check whether the sample being introduced is the same temperature as a human breath. In another case, a pressure switch has been designed into the system to check whether the force activating the system is as strong as a human breath.

The potential markets for these devices include traffic courts that may require drivers convicted of Driving While Intoxicated (DWI) to install such a device on their cars; parents of young drivers who may wish to exercise more control over their children; or persons who may want to impose more external control over their own conduct.

Two devices were tested by this research. These were: (1) The SOBERLYZER, developed by Mr. Jack Simon, 7066 Valley Green Circle, Carmel, CA 93923; and (2) The ALCOHOL BREATH IGNITION CONTROLLER (A. B. I. C.), developed by Renko, Inc., 32630 Cherryhill Road, Garden City, MI 48135. These devices were selected because they included extra features, designed to ensure that an individual has to actually blow into the breath tester.

The objectives of this laboratory research effort were to: (1) determine how well each device distinguishes between simulated breath samples above and below a set breath alcohol threshold level set by the manufacturer; (2) to determine whether any additional features of each device, such as the temperature and pressure sensors described above, work as they were designed; (3) to determine whether the systems' sensors can be fooled into responding positively to a sample introduced as if it were a real breath sample when it is not (i.e. non-alcoholic bogus breath samples); and
(4) to determine whether filters can be used to remove alcohol from breath samples so that the system does not detect alcohol above the set threshold even when the initial pre-filtered sample has alcohol above the threshold in it.

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* The data on which this evaluation is based were collected for NHTSA by Dr. Arthur L. Flores and Mr. Arnold Spicer of the U. S. Department of Transportation, Transportation Systems Center, Cambridge, Massachusetts 02142

SOBERLYZER

Method

The manufacturer supplied NHTSA with a hand held SOBERLYZER unit containing both an alcohol and a temperature sensor. The SOBERLYZER unit which was tested plugs into a power source packaged in a standard attache case. When installed in a car, the contents of the attache case would be permanently mounted out of reach of the driver, while the SOBERLYZER unit would be mounted on the dashboard for easy access by the driver.

According to information supplied by the manufacturer,

- o the alcohol concentration threshold above which the device would not allow a car to start was set at BAC = 0.025%.

- o each unit has a temperature sensor built into it so that the device would only allow a user to start the car if the breath source falls within the temperature range of 89°-98°F.

- o air samples must be continuously blown into the SOBERLYZER for five seconds to satisfy the system.

Laboratory tests were designed to determine: (1) how well the unit distinguished between breath samples above and below the reported breath alcohol threshold of 0.025%; (2) at what temperatures non-alcoholic breath samples allow a user to start a car; and (3) an assessment of the effectiveness of selected strategies that might be used by a driver trying to fool the sensors that control the interlock system.

Precision Testing

In order to test the accuracy of the 0.025% BAC threshold above, simulated breath alcohol samples were blown through the SOBERLYZER unit at the following BAC levels: 0.00, 0.005, 0.010, 0.015, 0.020, 0.030, and 0.050%. The simulated samples were generated by Smith & Wesson Mark IIA Breath Alcohol Simulator set at 93°F (34°C). This commercially available simulator consists of a 500 ml. glass jar into which both a thermostat-controlled heating element and an electric stirrer are immersed. The heating element and stirrer ensure that the premeasured alcohol solution in the simulator is of uniform concentration and constant temperature. When air is blown through the alcohol solution, the vapor given off the top of the solution simulates breath of the same alcohol concentration as the solution. The SOBERLYZER unit was exposed to ten (10) independent trials at each BAC level tested.

The Temperature Window

The SOBERLYZER unit was exposed to three independent trials of a non-alcoholic simulated breath sample at temperatures ranging from 71.6°-107.6°F (22°-42°C) in 2°C intervals. The temperature of the non-alcoholic simulated breath was systematically varied by immersing a copper coil into a laboratory water bath while passing air through the water bath in the same way a commercial simulator operates.

Strategies for Fooling the Sensors

Two different classes of strategies were used to see if the SOBERLYZER could be fooled. These were: (1) Non-alcoholic, bogus breath samples, and (2) Processed/Filtered-Alcohol Air Samples.

Non-alcoholic, Bogus Breath Samples. A series of alternative procedures were developed for introducing non-alcoholic, bogus air samples into the SOBERLYZER. For each procedure, care was taken to make sure the sample would be within the temperature range required by the SOBERLYZER's temperature sensor.

The alternative procedures tried were selected because they might be readily thought of by drivers and use items (e.g. appliances) that are found around the house or are easily obtained. These procedures involved use of a:

1) portable car vacuum cleaner

2) mylar plastic bag

3) portable hair dryer (12 volt)

4) standard toy balloon

The techniques used, when necessary, to warm the samples to approximate the temperature of human breath involved heating the sample with:

1) a portable hair dryer (12 volt)

2) wooden matches

3) a more powerful household hair dryer

4) body heat by holding it under an arm to warm it up.

For each bogus air sample procedure/heating technique combination, five independent trials were run.

Processed/Filtered-Alcohol Air Samples

Simulated alcohol breath samples were passed through different types of filters and then into the SOBERLYZER. The following filtering agents were used:

1) Common absorbents packed into paper tubing, e. g., cylindrical molecular sieve pellets, small crystalline silica gel fragments, commercial 'kitty litter', 'Drierite' - a commercial drying agent. A commercially available disposable breath test device, consisting of a glass tube which contains absorbent material, was also tested by passing alcohol directly through the glass tube.

2) A home-made water filter, constructed with a styrofoam cup and simple, commercially available rubber tubing.

3) Household cotton wadding packed into a paper tube, both dry and wet

4) Different types of tubing of varying sizes that might absorb alcohol themselves, such as copper and glass

5) Commercial cigarette filter material stuffed into glass tubing

6) A toy balloon blown up with a sample containing alcohol and stored for about 10 minutes and then rewarmed. The idea was that the balloon wall would serve as a membrane through which alcohol would escape without the balloon deflating.

In each case, the original simulated breath was set at either 0.03% or 0.10% BAC using a commercial breath alcohol simulator. The temperature of the simulated breath alcohol sample was held constant at 93°F. For each filtering agent at each simulated breath alcohol concentration, five independent trials were run.

Results

Precision Testing

The manufacturer stated that the threshold for activating the SOBERLYZER system was set at 0.025% BAC. The results of the precision testing are summarized in Table 1. The threshold BAC at which the SOBERLYZER was activated fell between 0.010-0.015% BAC. In other words, the SOBERLYZER was activated at a more stringent BAC level than indicated by the manufacturer, though the difference was not large.

Table 1

SOBERLYZER Precision Testing

(Determination of BAC level below which the ignition interlock system allows user to start car)

	SOBERLYZER UNIT
BAC of simulator (34°C)	NUMBER OF STARTS/NUMBER OF TRIALS
0.000	10/10
0.005	10/10
0.010	1/10
0.015	0/10
0.020	0/10
0.030	0/10
0.050	0/10

Alcohol Sensor Threshold: 0.010-0.015%

The Temperature Window

As indicated above, the manufacturer said the temperature range within which the SOBERLYZER could be activated was 89°-98°F. The actual range of temperatures within which one could start the car is shown in Table 2 (75-100° F). These results show that the measured range was 16°F wider than reported by the manufacturers.

Table 2

SOBERLYZER Temperature Range within which the ignition interlock system allows user to start car

Temperature of non-alcohol simulator solution	SOBERLYZER UNIT NUMBER OF STARTS/NUMBER OF TRIALS
22°C. (71.6°F.)	0/3
24°C. (75.2°F.)	3/3
26°C. (78.8°F.)	3/3
28°C. (82.4°F.)	3/3
30°C. (86.0°F.)	3/3
32°C. (89.6°F.)	3/3
34°C. (93.2°F.)	3/3
36°C. (96.8°F.)	3/3
38°C.(100.4°F.)	3/3
40°C.(104.0°F.)	0/3
42°C.(107.6°F.)	0/3
TEMPERATURE Range:	75°-100°F. (24°-38° C.)

Strategies for fooling the sensors

Non-alcoholic, bogus breath samples.

In Table 3 the results of tests to determine if non-alcoholic bogus breath samples would satisfy the ignition interlock system are summarized. For each test completed, five trials under identical conditions were run.

Regarding use of a portable vaccuum cleaner which sucks air from the SOBERLYZER unit, it consistently satisfied the SOBERLYZER, even at room temperature. It should be noted that the alcohol sensor inside the device normally heats up whenever it is in use, and effects the temperature of air close to it. To explain how this sucking action worked, even at room temperature, it was hypothesized that non-alcoholic air drawn over the heated alcohol sensor by the sucking action satisfied the temperature requirements of the system.

When the mylar plastic bag was used, it proved necessary to warm up the air in the bag to satisfy the temperature requirement of the SOBERLYZER. However, ordinary wooden kitchen matches produced enough heat to satisfy the temperature sensor without catching the mylar material on fire. As Table 3 shows, this procedure and use of a household hair dryer to warm the bag's contents, "fooled" the SOBERLYZER, whereas other heating techniques did not heat up the sample enough to satisfy the temperature requirements of the system.

When using a portable hair dryer as a direct source of air, its built-in heating element proved sufficient to satisfy the temperature requirement of the SOBERLYZER units. Connecting the hair dryer to the SOBERLYZER with a short piece of tubing proved an effective way to consistently satisfy the interlock system.

Regarding use of a standard toy rubber balloon, a number of alternative procedures were attempted. When the balloon was filled with air at room temperature, forcing the air sample through the SOBERLYZER did not satisfy the requirements of the temperature sensor. However, when the balloon was allowed to remain connected to the SOBERLYZER in a limp state for 5-10 seconds, after air had been exhausted from it, the temperature sensor was satisfied. Apparently, leaving the balloon connected allows air in a closed system to be heated enough by the alcohol sensor to satisfy the temperature requirements of the interlock system. When the portable hair dryer was used to warm the expanded balloon's non-alcoholic contents, it proved inadequate to heat the balloon enough to satisfy the SOBERLYZER temperature sensor. Using wooden kitchen matches also proved inadequate, as the balloons were too fragile to withstand the heat of the matches. Many balloons were destroyed when attempting this procedure. However, the heat given off by a household hair dryer was sufficient to heat the balloon's contents to the temperature required, thereby satisfying the SOBERLYZER's interlock system.

Table 3

SOBERLYZER Performance using non-alcoholic, bogus air samples

Source of Air Sample	Temp. Condition	SOBERLYZER NUMBER OF STARTS/NUMBER OF TRIALS
Portable vacuum cleaner	Room temp.	5/5
Mylar plastic bag	Room temp.	0/5
	heated with portable hair dryer	0/5
	heated with wooden kitchen matches	5/5
	heated with household hair dryer	5/5
	heated by holding under arm for 5 min.	0/5
Portable Hair Dryer (direct connection)	internal heater in dryer	5/5
Standard Toy Balloon (direct connection to SOBERLYZER)	room temp.	0/5
Standard Toy Balloon (direct connection to SOBERLYZER; in limp state after air exhausted through SOBERLYZER)	room temp.	5/5
Standard Toy Balloon	heated with wooden kitchen matches	0/5
Standard Toy Balloon	heated with portable hair dryer	0/5
Standard Toy Balloon	heated with household hair dryer	5/5

Processed/Filtered-Alcohol Air Samples

The results of procedures used when attempting to filter out alcohol from simulated breath samples are summarized in Table 4. For each procedure undertaken, five independent trials under identical conditions were run. Simulated breath samples at BAC = 0.03% and 0.10% were blown through various filters into the SOBERLYZER. Simulated breath samples were generated with the commercially available Smith & Wesson Mark IIA breath simulator described above.

In the first class of filtering agents cited in Table 4, a homemade water pipe was made with a styrofoam coffee cup and some rubber tubing. The alcohol in the simulated breath samples was filtered out when bubbled through the water, even when the original simulated breath was as high as BAC = 0.10%. Lukewarm water was used in the styrofoam cup to make sure the temperature requirements of the SOBERLYZER system were met.

In the second class of filtering agents cited in Table 4, different absorbents were packed into hollow paper tubes through which simulated breath samples were blown. The following absorbents filtered out alcohol from the simulated breath source: molecular sieve pellets, silica gel, commercial "kitty litter", and commercial "Drierite" composed of calcium sulphate. Commercially available disposable breath test devices, composed of glass tubes packed, in part, with absorbent material, also effectively filtered out alcohol.

As Table 4 also indicates, the following materials failed to filter out alcohol from simulated breaths: household cotton wadding loosely packed in tubing, different sized copper and glass tubing, and cigarette filter material stuffed into glass tubing.

Finally, when an alcoholic breath sample was used to blow up a rubber balloon and allowed to remain in the balloon for ten minutes, the balloon content exhausted through a SOBERLYZER was of low enough alcohol content to satisfy the SOBERLYZER. Though direct evidence was not obtained, it is assumed that alcohol passed through the balloon wall while air remained behind, though the remaining air still needed to be heated to satisfy the temperature requirements of the system.

Table 4

SOBERLYZER Performance using Processed/
Filtered Alcohol Breath Samples

Absorbent/Filtering Agent	BAC from Simulator (34°C.)	SOBERLYZER NUMBER OF STARTS/NUMBER OF TRIALS
Homemade Water Filter	0.00	5/5
	0.03	5/5
	0.10	5/5
Molecular sieve packed in paper tubing	0.03	5/5
	0.10	5/5
Silica Gel packed in paper tubing	0.03	5/5
	0.10	5/5
Commercial "Kitty Litter" packed in paper tubing	0.10	5/5
Commercial "Drierite" packed in paper tubing	0.03	5/5
	0.10	2/5
disposable breath tester composed of absorbent packed in glass tube	0.10	4/5
Household cotton packed in paper tubing (dry)	0.00	5/5
	0.03	0/5
	0.10	0/5
Household cotton packed in paper tubing (wet)	0.03	0/5

Table 4 (continued)

SOBERLYZER Performance using Filtered Alcohol Breath Samples

Absorbent/Filtering Agent	BAC from Simulator (34°C.)	SOBERLYZER NUMBER OF STARTS/NUMBER OF TRIALS
Copper Tubing	0.03	0/5
	0.10	0/5
Tygon (plastic) tubing	0.03	0/5
	0.10	0/5
Glass Tubing (3 different sizes)	0.03	0/15
	0.10	0/15
Toy Balloon filled with alcoholic breath sample	0.03	0/5
Same as above, 10 minutes later/warmed with household hair dryer	0.03	5/5
Toy Balloon filled with alcoholic breath sample	0.10	0/5
Same as above 10 minutes later/warmed with household hair dryer	0.10	5/5
"Carlton" cigarette filters packed into glass tubing	0.03	2/5
	0.10	0/5
"Lark" cigarette filters packed into glass tubing	0.03	0/5
	0.10	0/5

The Alcohol Breath Ignition Controller (A.B.I.C.)

Method

The manufacturer supplied NHTSA with a prototype A.B.I.C. device for testing. This device is intended for use as an ignition interlock system, where a user can not start his/her car unless the alcohol concentration of the breath blown into the device is below a fixed concentration. The device consists of a modified "Micronta" electronic breath test device.* In addition to an alcohol sensor, the A.B.I.C. also has a pressure sensor built into it, so that the breath pressure would have to be stronger than a preset threshold to satisfy the ignition interlock system. There is no duration of blow requirement for this device.

Laboratory testing of this device considered: (1) at what threshold it distinguished between simulated breath samples, passing samples whose BAC were below the threshold and failing BACs above that set level; (2) at what breath flow rate/pressure the device would satisfy the ignition interlock system; and (3) an assessment of one strategy using a non-alcoholic, bogus breath sample to fool the sensor controlling the interlock system.

Precision Testing

The manufacturer reported that the BAC threshold at which the A. B. I. C. distinguished between passing and failing breath samples was set at 0.10%. Simulated breath alcohol samples were blown through the A.B.I.C. unit at the following BAC levels: 0.000%, 0.010, 0.020, 0.030, 0.050%, 0.070%, and 0.10%. The simulated samples were generated by the same Smith & Wesson Mark IIA breath simulator described above. Ten trials at each BAC level were run. In order to ensure that the device was reacting only to the breath BAC levels, the pressure sensor was bypassed for these specific tests.

The Pressure Requirement

The breath flow rate necessary to satisfy the requirements of the ignition interlock system was measured by placing the entire device is a closed chamber in which a measured flow of non-alcoholic air could be gradually increased until the pressure requirement of the system was met. Five trials were run following this procedure.

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*The "Micronta" is a personal use breath tester that is/was available to the public from Radio Shack, Inc. and is manufactured by Delta Laboratories, Inc. (1957 Pioneer Road, Huntingdon, PA 19006)

Strategies for Fooling the Sensors

Only one procedure for introducing a non-alcoholic bogus breath sample was undertaken, as the pressure requirements of the system were quite high. In this case, a large plastic syringe was modified so that it could be held directly against the mouthpiece of the breath tester. By quickly closing the plunger of the syringe, enough pressure is created on the pressure switch to satisfy the pressure requirement of the system, while also satisfying the alcohol requirement because the air sample in the syringe was alcohol-free. Five trials were completed using this procedure.

Strategies involving use of various types of filtering agents could not be tested with the breath simualtion equipment available to us, because the pressure created when blowing through the simulators was not great enough to satisfy the pressure requirements of the A. B. I. C. Therefore, none of the techniques used when testing the SOBERLYZER could be attempted using the A.B.I.C. While we could not test the A. B. I. C. using these procedures, it might be feasible that a drinking user could filter alcohol out of his/her breath while still creating enough pressure to satisfy the pressure requirements of the system. However, procedures using dosed human subjects were beyond the scope of this effort.

Results

Precision Testing

The results of the precision testing are summarized in Table 5. The manufacturer had indicated that the threshold of this device was set at 0.10% BAC. However, according to our data, the threshold of this device was measured to be between 0.02% BAC and 0.05% BAC. In other words, 100% of the trials at or above BAC = 0.05% would have prevented a user from starting the car. The device consistently distinguished between samples below 0.05% from those at or above 0.05%.

The Pressure Requirement

The blowing rate required to activate the device and allow a user to start a car is 1.0 liters/second, based on five trials of testing. Once the pressure switch is satisfied, even by a short burst of air, only the alcohol threshold remains to be satisfied. There is no requirement of how long the breath must be blown into the breath tester to activate the system.

Table 5

BAC Precision Testing of the A.B.I.C.
in-vehicle breath tester

BAC of simulator solution	Outcome* OUT OF TEN TRIALS	
	PASS	FAIL
0.000	10	0
0.010	10	0
0.020	6	4
0.030	5	5
0.050	0	10
0.070	0	10
0.100	0	10

For comparison purposes, it should be noted that there are three different flow rates used when testing evidential breath test devices with the Breath Alcohol Sampling Simulator (BASS) developed by the U. S. Department of Transportation's Transportation Systems Center in Cambridge, Massachusetts (see Flores, et al., 1981). The flow rates are 0.2, 0.33, and 0.5 liters/second. In other words, the maximum flow rate used when testing evidential breath test equipment with the BASS is still only half as strong as that required to activate the A.B.I.C. A person of small stature with a low lung capacity may have difficulty activating the A.B.I.C., no matter what his/her BAC is.

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*The A. B. I. C. display has a red, yellow, and green light on it. A trial was considered a "Pass" when the green or yellow lights were illuminated. When the red light was illuminated, the trial was considered a "Fail." The device is designed so that a car can be started under either PASSING condition, as long as the pressure requirements of the system have also been satisfied.

Fooling the Sensors

Regarding bogus breath samples, a procedure that allows a user to introduce a short burst of non-alcoholic air into the breath tester consistently satisfied the pressure triggering system. Use of the modified syringe described above consistently satisfied the system in all five trials run.

Discussion/Conclusions

Regarding the performance of the SOBERLYZER's breath alcohol sensor, this device distinguished 100% of the time between simulated breath samples above and below a specific BAC threshold (i. e., 0.015-0.020%). The actual threshold proved to be about 0.015% BAC below (i. e., more stringent than) the 0.025% BAC level the manufacturer reported. However, the difference between the actual threshold and what it was purported to be is not great.

The range of temperatures within which the SOBERLYZER allowed us to start a car was much wider than reported by the manufacturer and it proved relatively easy to satisfy the temperature requirement of the system.

Regarding the performance of the alcohol sensor in the A. B. I. C., this device did distinguish between simulated breath samples above and below a BAC threshold of 0.05%, though less precisely than the SOBERLYZER. However, this measured threshold was half the concentration the manufacturer said it was (0.05% BAC vs. 0.10% BAC).

Regarding the breath pressure required to activate the A. B. I. C. system, it proved to be so great that an average person must blow as hard as he/she can to satisfy it. It is probable that a person of small stature with a minimum lung capacity of about two liters may be unable to satisfy the pressure requirement of the system as it is currently set.

Regarding procedures used to "fool" the sensors, this research clearly and consistently demonstrates that the current generation of in-vehicle breath testers can be fooled by introducing bogus, substitute breath samples. In the case of the SOBERLYZER, it was also demonstrated that alcohol could be easily filtered out of breath samples before they were blown into the device. Strategies that filter alcohol from breath samples could not be tested on the A. B. I. C. because the pressure created by blowing through the breath alcohol simulators was not great enough to activate the A. B. I. C.'s pressure sensor.

Only one prototype unit of each device was tested in this research project. Therefore, it is inappropriate to generalize these results to all current or future units. This evaluation is neither an endorsement of, nor an objection to product development in this area. Nevertheless, the findings should be useful to those who are attempting to develop practical in-vehicle breath test devices.

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