U.S. Department of Transportation

National Highway Traffic Safety Administration

DOT HS 807 394 **December 1988**

NHTSA Technical Report

Laboratory Evaluation of Two Passive Alcohol Sensor Devices

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Technical Report Documentation Page

1. Report No. DOT HS 807 394	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle Laboratory evaluation of two passive alcohol sensor devices		5. Report Date December 1988
		6. Performing Organization Code NRD-42
7. Author(s) Alfred J. Farina		8. Performing Organization Report No.
9. Performing Organization Name and Address Office of Driver and Pedestrian Research Research and Development National Highway Traffic Safety Administration 400 7th St., S.W., Washington, DC 20590		10. Work Unit No. (TRAIS)
		11. Contract or Grant No.
12. Sponsoring Agency Name and Address Department of Transportation National Highway Traffic Safety Administration 400 7th Street, S.W. Washington, DC 20590		13. Type of Report and Period Covered Technical Report April 1985 - December 1988
		14. Sponsoring Agency Code
15. Supplementary Notes		

16. Abstract

Passive alcohol sensing devices are designed to detect the presence of alcohol in a person's normally-expelled breath; they are "passive" in that one is not required to blow into a mouthpiece as with conventional breath test devices. The NHTSA tested two such devices (Lion Alcolmeter PAS, and a modified version of the Alcolmeter, the P.A.S.™) in the laboratory in two separate studies. The effects of several operational variables (subject-to-sensor distance, breath force, temperature, alcohol concentration level, crosswinds, and potential contaminants) on device performance were examined. The main finding was that each device was able to discriminate among differing alcohol air samples to a useful degree under laboratory conditions. Testing confirmed the need for strict adherence to recommended operating procedures regarding storage temperatures, avoidance of crosswinds, and proper measurement distance. Quality control was a problem in the P.A.S.™ prototypes. The NHTSA findings are limited in that they were conducted under laboratory conditions which do not reflect all the factors relevant to use of these devices. Issues such as quality control, long-term reliability, evasive strategies of non-cooperating drivers, and the legal status of passive-sensing technology were not formally examined.

17. Key Words Passive alcohol sensor blood alcohol measurement	18. Distribution Statement This document is available to the U.S. public through the National Technical Information Service, Springfield, VA 22161

19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page)	21. No. of Pages	22. Price

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

SUMMARY

Passive alcohol sensing devices have been developed to improve a police officer's ability to detect potential DWI offenders at roadside. The passive sensor examines the ambient air around a driver for ethyl alcohol (ethanol). The device is designed to indicate to the officer whether or not there is sufficient alcohol present to pursue a more comprehensive evaluation of the driver.

Two noninvasive alcohol screening devices, designed to serve as decision-making aides in the screening and detection of alcohol-involved drivers, were tested by the NHTSA in the laboratory. The laboratory personnel and test facilities of the Transportation Systems Center (TSC) performed all of the tests on both devices. One device, the P.A.S.TM is a modified version of the other, the Lion Alcolmeter. Both devices use the same fuel cell sensor for measuring ethanol. The devices differ mainly in their data displays, one (the Alcolmeter) using a numerical output while the P.A.S.TM uses a ten color-coded light bar display.

Multiple units of the devices were tested under laboratory conditions with an alcohol breath simulator used in place of human subjects. Some testing with the Lion Alcolmeter was also done in the field to determine the effects of certain contaminants and crosswinds. The main finding is that each device was able to discriminate among differing alcohol air samples to a useful degree under laboratory conditions.

The Lion Alcolmeter was quite sensitive to alcohol-based mouthwashes, but less so to a variety of other potential contaminants (aftershave, cigarette smoke, engine exhaust fumes). Relatively minor (.56 mph) crosswinds created in the laboratory prevented valid measurements from being made. Limited field tests on five different days showed, with outside wind speeds averaging between 1.0 to 5.8 mph, and both the driver and passenger windows open, that acceptable measurement conditions (less than .50 mph) rarely occurred inside the vehicle. However, under these same wind conditions, but with <u>only the driver window open</u>, there was no measurable crosswind near the driver the large majority of the time. Due to common physical components, it is assumed that the P.A.S.TM device shares these sensitivities. Testing confirmed the need for strict adherence to recommended operating procedures, i.e., ensuring that the subject talks while a measurement is taken; observing proper temperature cautions in storing the device; avoiding crosswinds; and, maintaining a six-inch distance between the subject's mouth and the device. (Note: Due to the P.A.S.TM tendency to read high, a nine-inch distance reduced its readings but also corrected them; this was not the case with

the Lion Alcolmeter where using a nine-inch distance lowered its accuracy.) Operator training takes on importance with the demonstrated need for adherence to stated operating procedures.

The P.A.S.™ device may have quality control problems not shared by the Lion Alcolmeter. Several P.A.S.™ units were tried before a usable set of three was available for test.

The NHTSA findings are limited in that they were conducted under laboratory conditions which do not reflect all the factors relevant to use of these devices. Issues such as quality control, long-term reliability, evasive strategies of non-cooperating drivers, and the legal status of passive sensing technology were not formally examined.

Table of Contents

II. The P.A.S.™

LIST OF TABLES

LIST OF FIGURES

I. THE LION ALCOLMETER PAS (PASSIVE ALCOHOL SENSOR)

INTRODUCTION

Within recent years a new type of alcohol-sensing device has become available to law enforcement personnel for use in detecting alcohol-impaired drivers. Called "noninvasive alcohol screening devices", their key feature is that they are designed to detect the presence of alcohol in a person's normally-expelled breath, with no active cooperation needed from the person being tested. The National Highway Traffic Safety Administration (NHTSA) evaluated two versions of such a device in the laboratory.

The first device was the Lion Alcolmeter PAS (Passive Alcohol Sensor) developed by Lion Laboratories Ltd., in collaboration with the Insurance Institute for Highway Safety. The second device was a modified version of the Lion Alcolmeter PAS, as developed by the U.S. distributor and licensee, National Patent Analytical Systems, Inc.. The modified device is known as the P.A.S.™ (Passive Alcohol Sensor). As of this writing, both devices were on the market although the distributor's intent is ultimately to focus on the P.A.S.™ as its principal offering. Part I of this summary is devoted to the test of the original Lion Alcolmeter PAS device; test results for the P.A.S.™ are presented in Part II.

Intended Use of Passive Sensor -- Typically, the roadside interview at a sobriety checkpoint provides a difficult environment for police officers to identify a potential DWI offender. Research has shown that police officers only identify a small percentage of actual DWI offenders that they observe at the roadside sobriety checkpoint interviews. Part of the reason for this is that the interviews are usually very brief, lasting less than a minute, and the officers have seen no observable driving behaviors that would alert them to impairment. Many drivers, although their driving ability may be significantly impaired, do not exhibit overt signs of impairment during the brief interview. Consequently, more often than not, they are not identified and are allowed to continue their DWI trip.

The passive sensor was developed to increase an officer's ability at roadside to detect potential DWI offenders. It is designed to examine the ambient air around the driver for ethanol (ethyl alcohol). The readout provided by a passive sensor device would indicate to the officer whether or not there is sufficient alcohol present around the driver to suggest a more comprehensive evaluation of the driver for potential driving under the influence of alcohol. For the devices in question, the recommended way for the officer to interview drivers would be to approach the vehicle and shine the flashlight portion of the device into the vehicle as safe traffic interviews dictate. The device would be held within six inches from the driver's mouth, under the pretext of examining credentials or the vehicle interior. While interviewing the driver, the officer would activate the alcohol sensing features of the device. The officer should not need to ask the driver to participate in the test in any way.

If a positive breath alcohol is observed, the officer would then proceed as he would with any DWI investigation. The passive sensor does not provide probable cause, but it alerts the officer to a potential DWI offense and gives him or her the opportunity to check the driver over thoroughly for signs of impairment that could lead to an arrest.

Lion Alcolmeter PAS Description

The Lion Alcolmeter PAS resembles a large flashlight, but contains a mechanism capable of drawing a sample of exhaled air from in front of the subject's face, and testing that air sample for the presence of alcohol. The PAS does not require a person to blow into a mouthpiece; rather, a person provides a sample by breathing through the nose or mouth or talking naturally while the unit is held about six inches from the face. The PAS device produces a three-digit "score" which, while not a direct blood-alcohol concentration (BAC) readout, is a measure designed to increase as the alcohol level increases.

TEST CONDITIONS

NHTSA tested the PAS's responses to a variety of alcohol (BAC) levels, device-to-subject distances, and exhalation (breath force) forces. Specifically, seven alcohol levels were tested (0.00, 0.02, 0.05, 0.08, 0.10, 0.12, and 0.15% BAC), along with three distances (6-, 9-, and 12-inches), and three breath force levels (light breathing, normal breathing, and talking). In addition, the effects of potentially-interfering substances (mouthwash, aftershave lotion, cigarette smoke, and engine-exhaust fumes), and of crosswinds on the device's operation were examined. All of the main tests were conducted at room temperature (approximately 70^{O}F). The laboratory personnel and test facilities of the Transportation Systems Center (TSC) performed all of the actual tests. Finally, separate tests were made by TSC to determine the effect of storing the device at temperatures below that recommended by the manufacturer.

An alcohol simulator was used to deliver an air sample of specified alcohol content across an air gap (device-to-subject distance) to the PAS unit at a specified breath-force level. The PAS score was recorded for each observation. Ten (10) observations were made for each experimental condition.

RESULTS

Decision Outcomes -- The information available for interpreting the numerical scores produced by the PAS was that a score of thirty (030) indicated that the person being tested had a BAC equal to or greater than 0.05%. This assumed proper calibration of the device, along with its use under recommended conditions, i.e., holding it approximately six-inches from the subject's mouth while he was talking, avoiding high winds, proper operation of the switches, etc. The equation of a score of 030 with a .05% BAC can be taken as a "scoring key", so to speak, that is used throughout the study. When tested under these ideal conditions, and using the above scoring key, the decision-making qualities of the PAS device were assessed. The performance of the device was measured in terms of its ability to identify where a particular air sample "belonged", i.e., above or below 0.05% BAC.. The main decision outcomes used are defined as follows:

TRUE POSITIVE = The device correctly identifies .05% BAC or higher air samples as being .05% BAC or higher stimuli.

FALSE POSITIVE = The device incorrectly identifies below .05% BAC air samples as .05% BAC or higher stimuli.

Two other measures (True Negatives and False Negatives) are complements of the False Positive and True Positive measures, respectively, and are not presented in the following Tables. Table I-1. shows performance under ideal conditions.

TABLE I-1. Decision-Making Performance of PAS Units Under Ideal Recommended Conditions (6-Inch Distance, Simulated Talking, No Wind, No Contaminants, Proper Operation).

TRUE POSITIVE	FALSE POSITIVE
100%	0%

This says, for the conditions indicated, that the device was completely accurate in its decisions. That is, the device was able to accurately discriminate between alcohol samples of .05% or higher and those samples below .05%, making neither false positive nor false negative type errors.
Having seen what the PAS device did under the ideal conditions, it was of interest to see whether its decisional accuracy changed when departures from the ideal occur.

Distance -- As seen below, distance is an important variable for the PAS device. True positive and false negative performance worsen as distance increases beyond the ideal of 6-inches. Using the same scoring key (030 = .05% BAC), the following decision outcomes were obtained as distance increased (see Table I-2.):

Breath Force -- Breath force was also an influential variable, though less potent than distance in affecting decisions made using the device. In Table I-3., the box labelled "COMBINED" condition is an average of the three breath force levels, reflecting the fact that the driver's breath force level is not directly under the control of the police officer. That is, there will be periods when the breath forces of the drivers tested in the real world will range across the breath force continuum; the performance figures shown here reflect what the average decision-making performance would be under such conditions.

TABLE I-2. Decision Outcomes as a Function of Subject-to-Sensor Distance. (All other test variables combined.)

DISTANCE	True Pos.	False Pos.
6-inches	87%	0%
9-inches	65%	0%
12-inches	47%	0%

TABLE I-3. Decision Outcomes as a Function of Various Breath Forces. (All other test variables combined.)

BREATH FORCE	True Pos.	False Pos.
Lt. Breath.	65%	0%
Norm. Brth.	100%	0%
Talking	100%	0%
COMBINED	88%	0%

<u>Distance and Breath Force</u> -- Having seen the effects of variations in both distance and breath force <u>singularly</u> on the decision outcomes made using the PAS units, it is of interest to note their <u>combined effect</u> in Table I-4.. Notice that the Table lists only the True Positive score; the False Negative score is the complement, i.e., TP = 60, FN = 40. All BACs below .05% were correctly classified (True Negatives = 100 percent) for all conditions and no False Positive errors were made. These results are for the standard scoring key (target BAC = .05, cutoff score = 030).

The last cell in the Table deserves comment. Any sample of measurements in the real world may involve both a range of breath forces and a range of distances; hence, the last "COMBINED +" cell merges all three breath forces and two distances (6- and 9-inches). This may be the most reasonable estimate of device performance, taking into account as it does variability in both device-user distance and the subject's breath force.

The performance under these conditions indicated that the PAS device was 77 percent accurate in detecting true BAC targets of interest (0.05% BAC or greater); 100 percent accurate in identifying true non-targets (BACs < 0.05); did not falsely identify any non-target as a target (zero False Positives); and, erred in allowing 23 percent of the true targets to go undetected. This is perhaps the most realistic estimate of the PAS's decision-making

TABLE I-4. Decision Outcomes (True Positive Scores Only) as a Function of the Combined Effects of Distance and Breath Force

	6-inches	9-inches	12-inches
Lt. Breath.	65%	18%	1%
Norm. Brth.	100%	88%	68%
Talking	100%	88%	71%
COMBINED	88%	65%	47%
COMBINED +	77%		

capabilities for the 0.05% BAC target level in that it reflects reasonable variations in both distance and simulated driver breath-force levels in a laboratory setting.

Discussion

The major question posed for this study was the usefulness of the PAS device as a decision-making aid for law enforcement officials in identifying alcohol-involved drivers. The Lion Alcolmeter PAS achieves its acceptable decision-making performance by being sensitive to alcohol. Its shortcomings come about due to its sensitivity to variations in operating conditions -- distance to the alcohol source, and variations in the force of the air stream being sampled. (The "shortcomings" -- or operating restrictions -- were previously noted by the manufacturer in the Instruction Manual; this study served mainly to quantify their effect upon performance). Distances beyond the recommended six-inches act to decrease the true positive detection capability by about six to seven percent per inch. Failure to acquire an adequate air sample (characterized as "normal breathing" or "talking") will also result in markedly poorer detection performance. If operational errors combine (far distances and low breath forces), then performance will degrade considerably. But with proper attention to stated operating procedures, the PAS device is capable of fulfilling the detection function ascribed to it. Given that it worked, the final step was to determine the effects of potentially-interfering substances and crosswinds upon PAS performance.

Contaminants -- The purpose of this part of the test effort was to see if the PAS device was sensitive to potentially-interfering substances which might mimic the presence of alcohol, or temporarily damage the device and cause false readings. The substances tested included a breath freshener (Listerine Antiseptic), aftershave lotion (Mennen Skin Bracer), cigarette smoke, and the exhaust fumes from a car (gasoline) engine. The mouthwash and the aftershave lotion both contained alcohol as an ingredient; these substances were tested in the laboratory using human subjects. Tests involving cigarette smoke and exhaust fumes were conducted outdoors.

The trial scores for the various substances were averaged and examined to see whether -- in and of themselves -- they were capable of evoking a response from the PAS units equal to the threshold score of 030 which presumably signaled the presence of an .05% BAC or higher alcohol stimulus. Several means were available for each substance depending on whether that substance was tested over time, or at different distances, or in various quantities. The largest mean for each substance was chosen from the several means available for it. Table I-5. presents the contamination findings.

TABLE I-5. Highest Average PAS Scores Obtained for Various Potential Contaminant Substances

SUBSTANCE	MAXIMUM AVERAGE SCORE
Mouthwash:	
1st minute	284
3rd minute	98
5th minute	48
7th minute	23
Aftershave	16
Cigarettes	
n = 1	9
n = 2	21
Engine Exhaust (1.5 ft.)	8

All of the substances evoked a response from the PAS device, but obviously not to the same degree. The device was responsive to substances containing alcohol - as one would expect and want it to be - with a very strong response made to "mouth alcohol substances" in contrast to "skin surface alcohol substances". Mouth alcohol substances were fully capable of triggering an alcohol alerting score (i.e., 030 or higher) in and of themselves; this possibility continues, as indicated, for about five to six-minutes after use. Skin-surface alcohol substances were unlikely to trigger an alerting score by themselves, but they conceivably could combine with a true below threshold alcohol level to evoke an alerting score from the device; the time course of such an effect would be quite short, however, with rapid dissipation occurring five to seven minutes after application.

No alcohol alerting score was generated by either one or two cigarettes, although two cigarettes might provoke a contributory reaction if some low level of alcohol was present in the driver. No disabling effects were noted for the devices as a result of exposure to the smoke. Engine exhaust fumes do not appear to pose a problem to measurement activities.

Crosswind -- The highest crosswind the device could tolerate in the laboratory was approximately a half-mile-per-hour (mph) breeze. Crosswinds above .56 mph reduced the device's response to a 0.10% BAC stimulus to a negligible reading. Such a crosswind would disperse all traces of the alcohol-ladden airstream before it reached the sensor. This raised the question of what real-world conditions might be. Limited tests were conducted outside the laboratory on five different days using a real car, with external (outside the car) wind speeds ranging from 1.0 to 5.8 mph. Wind direction ranged from 9:00 o'clock to 12 o'clock with the front of the car being at 12 o'clock. Crosswind measurements made inside the car indicated that acceptable conditions (less than .50 mph) predominated when the driver's window was open and the passenger's window was closed. However, if both driver and passenger windows were open, acceptable conditions were almost never obtained.

Temperature -- We explored a situation where a user might violate the recommended storage temperature range (10-30°C or 50-86°F)), possibly by leaving the device in an unheated car on a cold night. Storing or "soaking" the device at -10°C (14°F) and at 4.5°C (40.1°F) for one hour, respectively, then testing at each of those temperatures, produced erroneously low readings.

Discussion

The principal effect of most of the contaminants tested was to add a small increment to the PAS score. Aside from mouth alcohol substances, none of the substances was capable of eliciting an alcohol alerting score (i.e., 030) by itself. Whether several different substances might combine to have an additive effect on the PAS score was not specifically tested. With the fairly rapid dissipation time for both mouthwash and aftershave, and the unlikely event that a driver would normally use either substance while driving, the chance of these posing a major operational problem is not great. The use of mouthwash (spray variety) by a driver might even raise the question of whether it was being used to cover up signs of drinking.

Regarding crosswinds, even a light crosswind can invalidate PAS operations if the user allows such a condition to exist. The officer could request that the car windows on the passenger side be closed. (Whether this request would turn the passive sensing operation into a "test" could be a potential issue for the courts to decide.) Or, the officer may try to position his body in the open driver's window so as to block off or reduce the crosswind. Failing that, the officer should realize that his measurements may not reflect the situation accurately if a strong crosswind exists.

Regarding low storage temperatures, users are cautioned not to exceed the manufacturer's recommendations.

CONCLUSIONS

The Lion Alcolmeter PAS (Passive Alcohol Sensor) is a noninvasive alcohol-screening device designed to serve as a decision-making aid in the screening and detection of alcohol-involved drivers. The tests conducted by the NHTSA found that the device was able to discriminate between above and below 0.05% BAC alcohol stimuli to a useful degree under laboratory conditions. When tested in accordance with recommended ("ideal") operating instructions and using a scoring key of 030 = .05% BAC, the device was 100 percent correct in all of its identifications and made no false identifications of either kind. These detection rates worsen when variations in distance and breath-force levels are introduced, but a credible level of performance was still maintained. Specifically, when averaged over a range of both distance and breath-force levels, the true-positive detection rate of 100 percent cited above was reduced to 77 percent.

Operation of the PAS is influenced by several <u>user factors</u> such as: the distance between the device and the alcohol source (driver), and the force of the breath exhalation. Variations in these factors away from the recommended operating conditions will decrease the decision-making qualities of the device. <u>Environmental factors</u> such as alcohol-based mouthwashes and the presence of crosswinds are also influential. The user and environmental factors range in their effects from influencing the device's score to abolishing it entirely, but appropriate operator training and adherence to operating procedures should be sufficient to counteract the effects of these factors. It should be noted that no tests were made of the device's performance over long time periods, e.g., months, nor were any of the maintenance requirements tested. Similarly, no attention was given to the legal status of passive sensing technology, nor to conditions involving noncooperative drivers.

II. THE P.A.S.™ (PASSIVE ALCOHOL SENSOR)

INTRODUCTION

The second device, reported on in this section, is the P.A.S.™ (Passive Alcohol Sensor), a modified version of the Lion Alcolmeter PAS. The P.A.S.™ was not available when NHTSA began testing the PAS model, but because of overlaps in certain design and operating characteristics, it was not considered necessary to repeat all of the extensive testing done on the PAS with the P.A.S.™. Consequently, a more limited test sequence was used with the P.A.S.™, one which benefitted from the earlier PAS test effort.

A principal difference between the two devices is in the output display which changed from a three-digit numerical readout in the older PAS to a "bar graph display panel" in the P.A.S.™. The bar graph display consists of ten color-coded light bars each indicating a BAC range (see Figure II-1.). The "approximate BAC" range information in Figure 1. is provided for the reader's guidance and does not appear on the actual device. Other differences in the P.A.S.™ included fewer batteries, a larger sampling of air, revised temperature recommendations, and a redesign of the outer case to make it look more like a flashlight. The weight of the device was reduced by about 37%, from 3.2 to 2.0 pounds.

Device Description

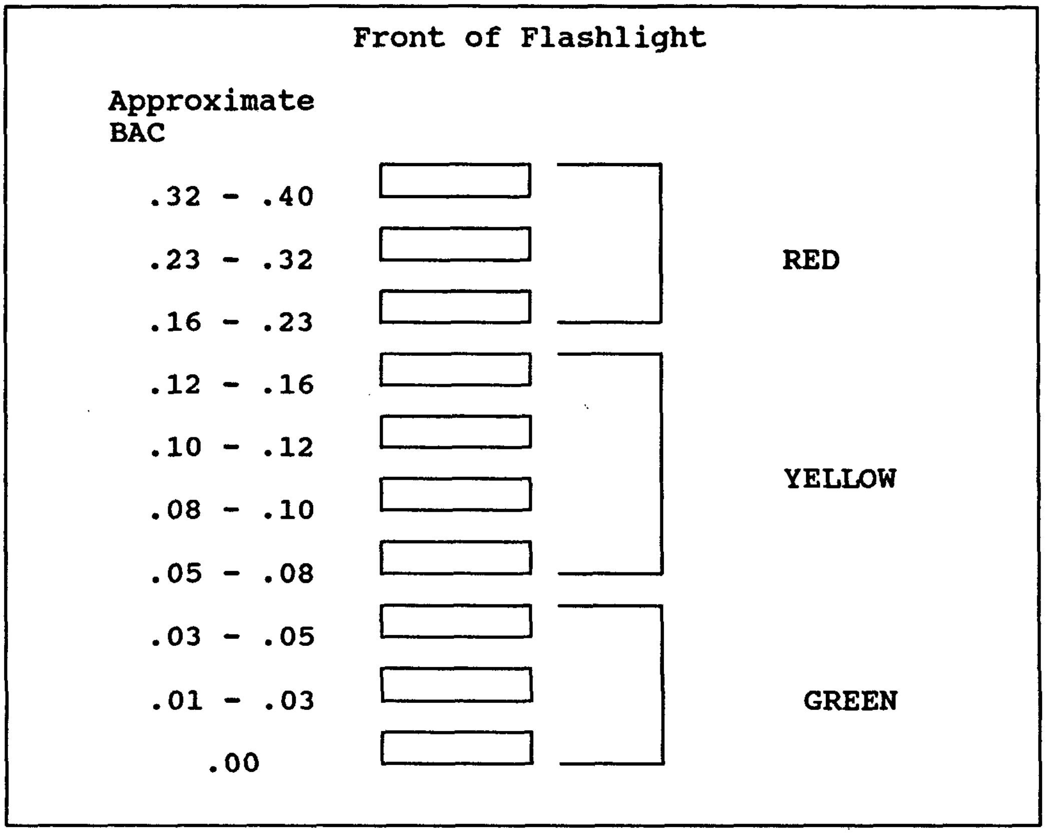
The P.A.S.™ sensor works in the same manner as the older PAS device as regards sampling and analyzing a subject's breath. Quoting from the Instruction Manual:

> "The P.A.S.™ sensor essentially consists of an alcohol detector built into a high-quality flashlight, with a powerful beam. The instrument also incorporates a small pump to draw in the breath from around the mouth of the subject, most commonly while talking. The breath is then taken directly into a fuel cell sensor for analysis. In the fuel cell sensor, any alcohol in the breath undergoes an electrochemical process to generate a small but measurable voltage. After electronic processing, the device displays the approximate (probable) alcohol level of the person from whom the breath sample was taken."

Regarding operation of the bar graph display, the manufacturer states:

(after taking the air sample) "watch the bars light up and wait about 20 seconds until peak reading is established....If no yellow bars light up, the subject can reasonably be considered not under the influence of alcohol....If the reading reaches the red bars, the subject is almost certainly over the legal limit."

FIGURE II-1. Bar Graph Display Panel of P.A.S.™
(BAC Figures Added)



Study Objectives

As with the PAS device, the main purpose of the tests was to assess the decision-making qualities of the P.A.S.™ in regard to the alcohol status of a driver. The manufacturer had changed two features which required retesting. One was the change in the output display of the device. The other was the change in the recommended temperature range for storing and using the P.A.S.™ sensor. Prior findings from the Lion Alcometer test concerning the effects of crosswinds, breath forces, and potential contaminants were taken as still being valid and applicable for the new P.A.S.™ sensor, given that the changes made in the new device did not appear to relate to these variables. Consequently, no new tests were made in these areas for the P.A.S.™.

TEST CONDITIONS

The midpoints of each of the BAC ranges represented by the color-coded light bars of the display (see previous Figure) were used as test points, along with the additional levels of 0.01, 0.03, and 0.05% BAC. A total of thirteen (13) BAC levels were tested. Two distances, 6-inches and 9-inches, were used. Three units of the P.A.S.™ device were used in the test. A single breath force level, representing a simulated "talking" condition, was employed. Each test condition was repeated ten times with a measurement being taken each time. The measurement was the number of the highest bar lit in response to a particular alcohol stimulus. All of the main tests were conducted at room temperature (approximately 70°F). The laboratory personnel and test facilities of the Transportation Systems Center (TSC) performed the actual tests.

Special temperature tests focused on the lower storage and operating temperature of 32°F cited by the manufacturer. It raised the question that if an officer was on a roadblock for one hour with an ambient temperature of 32°F, would the device be affected? Also, would using the internal heater of the P.A.S.™ compensate for the cold condition?

NOTE: The test laboratory experienced difficulties with four of the P.A.S.™ units provided by the manufacturer before finally acquiring three units which functioned properly and could be tested. Difficulties with the four early prototypes included: a misaligned calibration hole, a device that produced consistently high readings, a broken lead from the fuel cell, and an air pump that would not run when the flashlight was on. Three production type units were finally obtained and testing proceeded. The reader should also note other problems that occurred as mentioned in the Discussion section.

Alternate Scoring Approaches -- The 10-light bar output of the P.A.S.™ device offered several scoring approaches to assessing the decision-making qualities of the device. The approaches differ in terms of the preciseness of the decision the device is called upon to make. The three main scoring approaches used here included:

1) Light by Light -- compared the <u>expected</u> light value of each alcohol test stimulus with the <u>actual</u> light value response of the device

2) BAC Ranges -- determined how well the device correctly assigned the alcohol test stimuli to one of three ranges: Range One = .00-.05% (lights # 1-3), Range Two = .05% - .10% (lights # 4-5), and Range Three = .10% and above (lights # 6-10).

3) Color Zones -- determined whether the alcohol test stimuli belonging to the Green (light #1-3), Yellow (light # 4-7), and Red (light #8-10) Zones, respectively, received the same light zones on the response side?

The first approach (Light by Light) views the device as a breath tester and seeks almost one-to-one accuracy. The second approach (BAC Ranges) introduces the idea of BAC ranges which might have legal implications. The third approach (Color Zones) uses the device in a preliminary screening mode, seeing if it can allow a user to operate on a green-yellow-red basis. The color zone approach is the one advocated by the manufacturer. According to the manual, the three color zones have the following meaning:

GREEN -- "...reasonably considered not under the influence..."

YELLOW -- [No direct statement made by manufacturer, but implication is that subject can reasonably be considered under the influence of alcohol.]

RED -- "...almost certainly over the legal limit."

<u>RESULTS</u>

<u>Decision Outcomes</u> -- Table II-1. shows the decision-making qualities of the device when scored by the three approaches. These outcomes reflect the manufacturer's recommended distance (6-inch) and breath force (talking) conditions. The decision outcomes used are defined as follows:

TRUE POSITIVE = The device correctly identifies an alcohol stimulus, either in terms of the appropriate light number, BAC Range, or color zone.

FALSE POSITIVE = The device incorrectly identifies the alcohol stimulus as being a higher light value, BAC Range, or color zone than it actually is.

FALSE NEGATIVE = The device incorrectly identifies the alcohol stimulus as being a lower light value, BAC Range, or color zone than it actually is.

In general, the decision-making performance of the device improved as it was called upon to make less precise but still useful decisions, i.e., went from the individual light bar level to the zone level. The large percentage of false positive decisions, i.e., 58 percent, reflected the fact that, at 6-inches, the units often read at least one light bar higher than the alcohol test stimulus deserved[1].

As seen in Table II-2., when used at a 9-inch distance, the device's performance improved considerably. The improvement was due to the fact that increasing the distance acted to reduce the strength of the alcohol stimulus, thus bringing the "high" readings back into line.
And, if the assumption is made that device operators may waver between 6- and 9-inch distances when using the device, then the decision outcomes for the <u>combined</u> distances of 6- and 9 inches shown in Table II-3. may best represent what actually will result.

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[1] When told of the consistently high readings obtained at the 6-inch distance, the manufacturer concluded that the source of the problem was in the recommended calibration procedure, which they then modified. However, the TSC test laboratory was unable to accomplish the new calibration procedure as stated. The manufacturer then proposed a design change involving a different resistor value in the circuitry. The design change permitted the new calibration procedure to be followed. An abbreviated test protocol was run to determine the effect of the changes (resistor and calibration procedure). When scored in terms of color zones, the modification improved the situation in that small increases were noted in the percentage of true positive decisions while the percentage of false positive errors decreased. Within the color zones, performance was poorest in the green zone (.00 - .05%BAC).

TABLE II-1. Decision Outcomes at 6-Inches for Three Scoring Approaches Using Three Test Units.

Scoring Approach	True Pos.	False Pos.	False Neg.
Light by Light	34%	58%	8%
BAC Ranges	75%	25%	0%
Color Zones	81%	19%	0%

TABLE II-2. Decision Outcomes at 9-Inches for Three Scoring Approaches Using Three Test Units.

Scoring Approach	True Pos.	False Pos.	False Neg.
Light by Light	63%	9%	28%
BAC Ranges	95%	3%	2%
Color Zones	95%	2.5%	2.5%

Finally, these data indicated that following the manufacturer's recommended color zones yielded the best decision outcomes. Looking at the color zone performance more closely, Table II-4. shows what the decision outcomes were <u>within</u> the color zone themselves.

TABLE II-3. Decision Outcomes Combined Across Distances (6- + 9-Inches) for Three Scoring Approaches Using Three Test Units.

Scoring Approach	True Pos.	False Pos.	False Neg.
Light by Light	48%	34%	18%
BAC Ranges	85%	14%	1%
Color Zones	88%	11%	1%

TABLE II-4. Decision Outcomes Within Color Zones Across Combined Distances (6- + 9-Inches) Using Three Units

Color Zone	True Pos.	False Pos.	False Neg.
Green	82%	18%	na
Yellow	90%	10%	0%
Red	93%	na	7%

Temperature -- The temperature tests consisted of placing the three units in a 32°F environment and noting their responses to a fixed alcohol stimulus (0.065% BAC) at 15-minute intervals for up to a duration of one (1) hour. During these low-temperature trials, the units were tested with their internal heaters both on and off. For comparison purposes, the responses obtained to this same alcohol stimulus under room temperature (72°F) conditions were compared with the low temperature readings. There were no significant differences among the responses of the units to the various temperature/heater conditions over time. The units were temperature stable over time at their lower design limit.

Discussion

The P.A.S.™ device shows very credible performance when the user, as recommended, focuses on the color zones of the bar graph display. The color zone approach is forgiving of certain "within zone" type errors. For example, using all of the green lights as a single zone allows one to disregard the many small errors the device makes inside the green zone, e.g., where .01% BACs are predominately registered as .00% BACs. Such internal errors do not diminish the device's identification powers unless they occur on the edges of the zone and cause an identification to change from one zone to another. This type of error, as reported in the prior Tables, is more critical. As Table II-4 indicated, the device shifted a total of 18 percent of the alcohol stimuli that belonged in the green zone to the yellow zone. Similarly, ten percent of the alcohol stimuli belonging in the yellow zone were assigned to the red zone.

Regarding temperature, the units had no difficulty operating at their lower temperature boundary. However, anecdotal evidence suggests that violating the upper temperature boundary (104°F) may have more serious consequences. Six of ten units shipped to TSC during August were found to have electrolyte leaking from the fuel cell. The explanation, untested, was that the units may have experienced temperatures greater than 104°F as a result of delays incurred in the shipping process, i.e., they sat in a hot truck for several hours.

CONCLUSIONS

The P.A.S.™ (Passive Alcohol Sensor) is a noninvasive alcohol-screening device designed to serve as a decision-making aid in the screening and detection of alcohol-involved drivers. Compared physically to its predecessor -- the Lion Alcolmeter PAS -- the P.A.S.™ is lighter, uses fewer batteries, and is more convincing as a flashlight.

The device is best used as an alcohol screening device, i.e., to aid the making of yes-or-no type decisions based on broad indications (color zones), rather than on precise BAC measurements. When used within six-to nine-inches from an alcohol source under laboratory conditions, the device assigned alcohol air samples to the correct BAC zone 88 percent of the time, while making false positive errors 11 percent of the time, and false negative errors one percent of the time.

Based on similarities to its predecessor, it is assumed to share with the Alcolmeter a sensitivity to alcohol-based mouthwashes, crosswinds, and a variety of contaminants. It has adequate stability over time to low temperature conditions that are within its operating range. Temperatures which exceed its upper limit may have a real potential for doing damage to the device. Appropriate operator training and adherence to critical operating and storage procedures should be effective in counteracting these factors. It should be noted that no tests were made of the device's performance over long time periods, e.g., months, nor were any of the maintenance requirements tested. Similarly, no attention was given to the legal status of passive sensing technology, nor to conditions involving noncooperative drivers.

Based on the testing experience and anecdotal evidence, the P.A.S.™ device may have quality control problems, and a more secure means of shipping might have to be found to avoid high temperature problems. Both types of problems appear correctable.