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Traffic Safety
Administration**

Performance Evaluation: Balloon-Type Breath Alcoho Self Tester for Personal Use

OFFICE OF DRIVER AND
PEDESTRIAN RESEARCH
Problem-Behavior Research Division

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16. Abstract

The accuracy of the only breath alcohol balloon-type self test device being marketed for personal use (Luckey Laboratories DM-2) was assessed in the laboratory. Data regarding this self-test device's ability to accurately classify an individual as having 0.10% (or higher) Breath Alcohol Concentration level are reported. This level was selected because it is the legal per se limit for operating a motor vehicle in many states. The results indicate that, at optimal environmental test temperatures (around 75°F), a large proportion of individuals with BACs at or above this level would be inaccurately classified as below 0.10%. Also, at more moderate test temperatures (around 60°F), the extent of inaccurate classifications and the degree of underestimation of the actual BAC level increases substantially.

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METRIC CONVERSION FACTORS

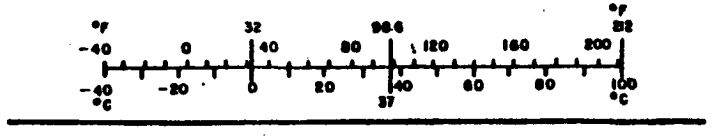
Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
	AREA			
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
	MASS (weight)			
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
	VOLUME			
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
	TEMPERATURE (exact)			
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
	AREA			
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
	MASS (weight)			
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
	VOLUME			
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
	TEMPERATURE (exact)			
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



PERFORMANCE EVALUATION: BALLOON-TYPE BREATH ALCOHOL SELF TESTER FOR PERSONAL USE

Theodore E. Anderson

Introduction

A number of balloon-type disposable breath alcohol testers are available. These "self testers" are relatively inexpensive and designed to provide an indication of whether an individual's breath alcohol concentration (BAC) is above or below specified levels (e.g., .10% - the per se legal limit associated with impaired motor vehicle operation in many states). The only balloon-type device marketed for personal use that could be located was the Luckey Laboratories DM-2 Disposable Tester. The other disposable breath testers (e.g. Draeger Alcotest) are marketed for police use only. Police are very concerned about the possibility of arresting someone whose BAC is, in fact, below the legal impairment level (e.g., 10%). Therefore, balloon testers manufactured for police use are typically designed to minimize false positive readings (i.e., the device indicates that the individual's BAC is above .10% when it actually is below that level). Unfortunately, designing a device to minimize the number of false positive readings will also typically produce an increase in the number of false negative readings (i.e., the device indicates that the individual's BAC is below .10% when it is actually above that level). From a personal use perspective, this condition (increased possibility of false negative readings) is particularly unacceptable. An individual wants to know whether it is legally permissable to drive, and the police-oriented balloon tester would be more likely to tell him that it is when in fact his BAC is above the legal limit. Therefore, the performance criteria for a balloon tester required by the police are essentially the reverse of the performance criteria the tester should have for personal use (i.e., a device that reduces the number of false negative readings, even at the expense of an increase in the false positive readings, would be more appropriate for personal use).

The primary objective of this research effort was to determine the performance accuracy of the Luckey Laboratories DM-2 device for personal use.* The DM-2 is inexpensive (one DM-2 kit which contains two test devices costs $1.75), small, and easy to use. Each kit contains: two toy balloons, two reaction tubes that contain material which interacts with the breath sample to indicate the alcohol level, and two short tygon tubes used to connect the balloon which has been inflated with the breath sample to the reaction tube. Brief instructions for performing the test and interpreting the test result are printed on the kit package. The reaction tube is a short glass tube packed with a column (approximately 3 cm long x 0.6 cm diameter) of crystalline materials. The crystalline materials consist of three yellow segments (bands) of potassium dichromate (yellow) absorbed in silica gel (colorless). The yellow bands are about 0.5 cm long and are separated by an inert material similar in appearance to beach sand. The inert material is also packed on either side of the outer yellow bands. The ends of the reaction column are protected from environmental vapors including water vapor by blue colored silica gel crystals and plastic caps. In the presence of water vapor, the blue crystals become colorless which indicates that the tube should not be used.

*The data that provide the basis for this report were collected for NHTSA by Dr. Arthur Flores (Transportation Systems Center).

To perform a self-test, one discards the end caps and blue crystals from the reaction tube. A balloon is then fitted with a tygon connector which is used as a mouthpiece. The balloon is inflated with a continuous breath, then connected to the reaction tube. Air from the balloon is supposed to pass through the reaction tube for exactly one minute, then the balloon which at this point is normally still partially inflated, is disconnected from the tube. Alcohol present in the sample, if any, is absorbed by the reactive crystals. Subsequent reaction with the absorbed alcohol converts the yellow dichromate to the green chromous form. The number of color bands that have turned from yellow to green indicate BAC. Color change of a single band indicates approximately 0.05 BAC, two bands 0.10 BAC, and three bands 0.15 BAC.

Method

Artificial breath samples, containing selected alcohol concentrations produced by a "breath alcohol simulator", were used to inflate the balloons. Breath alcohol concentrations ranging from 0.02% to 0.15% were tested. Balloon breath sample volume (2 to 6 liters) and environmental test temperature (57°F to 95°F) were also varied. The breath tester "color band" changes (yellow to green) resulting from passage of the alcohol breath samples through the reaction tubes, were estimated by the experimenter in 0.1 band intervals. The time to be allowed for color change to take place is not specified in the directions. Preliminary tests with the device indicated that very little additional color change occurs after two minutes. Therefore, two minutes was selected as the standard waiting period in the work reported below.

Results

For purposes of this report only a selected subset of the results will be presented. These include tests where the simulated BAC was at or above 0.10%, and the balloon breath sample volume was 2 or 3 liters. These results are considered to be the most important for the following reasons:

- The legal *per se* alcohol impairment limit in most states is 0.10%. The per se statute states that a BAC at or above the specified level is, by itself (no behavioral impairment evidence required), sufficient evidence to convict for DWI. It is therefore essential that the self-test device accurately inform the driver when he is at or above this limit. If the device indicates an individual's BAC is below 0.10% when in fact it is above 0.10%, the driver may think that it is legally permissable to drive. A subsequent DWI arrest might be challenged using the device's results as evidence.

- Breath samples in the 2 to 3 liter range are more likely to be produced than 6 liter samples, because of inherent vital capacity limitations and the individual's fear of breaking what appears to be, for the DM-2, a flimsy toy balloon.

Tables 1 and 2 summarize the results. The detailed trial by trial data are presented in Tables 3 and 4. For all these tables, "false negatives" refers to the condition where the DM-2 balloon tester inaccurately indicates that the individual's BAC level is below the legal impairment level (0.10% BAC). The percentage of false negatives varies from 43% to 100%. The magnitude and extent of this error appears to vary with environmental test temperature. The greatest accuracy appears for test temperatures around 75°F. For cooler temperatures (high 50s) the percentage of false negatives and the extent of BAC under-reporting is greatly increased (e.g., simulated BACs of 0.15% are estimated around 0.05% - see Table 4).

The above results are considered to be the most important. However, there are other observations relating to the use of the DM-2 that should be noted. These observations relate primarily to estimating the extent of band color change resulting from passage of the simulated breath alcohol sample. The initial yellow bands were bright and contrasted well with the colorless inert material. The color boundary sharpness and regularity was limited only by the particle size of the yellow active and colorless inert crystals. After passage of a test sample followed by a two minute wait, the resulting green color was rather dull and drab. The yellow color adjacent to the green color also became dull and drab. Thus, the contrast between the two colors was low. Also, the boundary between the two colors was diffuse and irregular. The occurrence of channeling of the air sample around unreacted dichromate was evident in some instances as yellow areas could be seen downstream from areas that had turned green. The process of "reading" the amount of color change was performed with a degree of uncertainty as to how much green has actually been produced.

Conclusions/Recommendations

- The information provided by a personal self test device should not be used as the only indicator of whether or not to drive. An individual should also look for other symptoms (e.g., double vision, deterioration in motor coordination, etc.) that may indicate his driving behavior is impaired. Even if an individual's BAC is below the specified legal level, he may be too impaired to drive. However, if the individual believes he is not impaired, an accurate self-test device could be used to confirm that his BAC is, in fact, below the legal limit. Therefore, the optimal personal self test device should produce very few false negative readings (i.e., tell the driver that he is below 0.10% BAC when he is in fact at or above this level).

- The Luckey Laboratories DM-2 Disposable Breath Test device produces a large proportion of false negative readings.

- Temperatures below 60°F that are considered likely to occur in outdoor self-test situations drastically increase the DM-2's under-reporting of the actual BAC and percentage of false negatives.

- The color changes in the device's alcohol sensitive "bands" are difficult to read and interpret.

- Based on the above, the Luckey Laboratories DM-2 Disposable Breath Test device (the only balloon-type self-test device known to be marketed for personal use) is not recommended for use by the driving public as an aid in determining whether their BAC is at or above 0.10%

TABLE 1

Summary of Balloon Tester Results
at Optimum Temperatures
(24-25°C/75-77°F)

Breath Sample Volume (liters)	BAC (%)	Number of Test-Trials	Correct Classifications (%)	False Negatives (%)
2	0.10	15	27	73
3	0.10	14	36	64
3	0.12	14	57	43

TABLE 2

Summary of Balloon Tester Results
at Moderate Temperatures
(15°C/59°F)

Breath Sample Volume (liters)	BAC (%)	Number of Test-Trials	Correct Classifications (%)	False Negatives (%)
3	0.10	2	0	100
3	0.12	2	0	100
3	0.15	2	0	100

TABLE 3

Balloon Tester Results by Test Trial,
Optimal Temperature (24-25°C/75-77°F)

	BAC = 0.10% Breath Sample Volume = 2 liters			BAC = 0.10% Breath Sample Volume = 3 liters			BAC = 0.12% Breath Sample Volume = 3 liters		
Test Trial	Band Change Observed (Expected:2.0)	Reported BAC (Actual:0.10)	False Negatives	Band Change Observed (Expected:2.0)	Reported BAC (Actual:0.10)	False Negatives	Band Change Observed (Expected:2.4)	Reported BAC (Actual:0.12)	False Negatives
1	1.7	0.085	X	2.0	0.100		1.1	0.055	X
2	1.7	0.085	X	2.0	0.100		2.0	0.100	
3	1.8	0.090	X	1.2	0.060	X	2.0	0.100	
4	1.7	0.085	X	2.1	0.105		2.1	0.105	
5	1.8	0.090	X	1.3	0.065	X	2.0	0.100	
6	1.5	0.075	X	1.2	0.060	X	1.8	0.090	X
7	2.2	0.110		2.0	0.100		1.9	0.095	X
8	1.4	0.070	X	1.4	0.070	X	1.8	0.090	X
9	1.8	0.090	X	1.8	0.090	X	1.9	0.095	X
10	2.0	0.100		1.2	0.060	X	1.5	0.075	X
11	1.5	0.075	X	2.9	0.145		2.1	0.105	
12	2.2	0.110		1.5	0.075	X	2.1	0.105	
13	1.4	0.070	X	1.9	0.095	X	2.3	0.115	
14	1.8	0.085	X	1.6	0.080	X	2.5	0.125	
15	2.0	0.100							
	Percent False Neg:	73%		Percent False Neg:	64%		Percent False Neg:	43%	

TABLE 4

Balloon Tester Results by Test Trial,
Moderate Temperature (15°C/59°F)
Breath Sample Volume - 3 liters

BAC	Band Change Observed	Reported BAC	False Negatives
0.10%	1.0	0.050	X
	1.2	0.060	X
0.12%	1.5	0.075	X
	1.1	0.055	X
0.15%	1.3	0.065	X
	1.0	0.050	X

Percentage False Negative: 100%