REVIEW AND OPINION

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The Role of the Forensic Scientist in the Application of Chemical Tests for Alcohol in Traffic Law Enforcement

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ABSTRACT: The role and ethical responsibilities of the forensic scientist are reviewed. The context of this discussion includes the application and support of chemical tests for alcohol statutes in the United States adversary system of justice. The goal of this review is to stimulate awareness among the various participants (that is, scientist, prosecutor, defense counsel, judges, and law enforcement officials) in traffic law enforcement situations. Their mutual understanding and cooperation is essential to the effective and efficient use of chemical test procedures. The relative scientific weight that should be given to blood, breath, and urine tests for alcohol is presented.

KEYWORDS: criminalistics, jurisprudence, breath-alcohol testing devices, witnesses

The methods and mode of application of chemical tests applied to the quantitation of alcohol in blood, breath, and urine have been reviewed and studied in meticulous detail by Mason and Dubowski [*1,2*]. Such review and study has had both beneficial and detrimental effects on the administration of justice in our adversary system.

The benefits of this intensive review and study have been to raise the level of accuracy, reliability, and the standards of practice for the forensic application of chemical tests for alcohol. In light of the high standards of practice and efficiency made possible by existing methods and equipment, the many improvements or refinements in test methods and hardware profferred by equipment manufacturers, particularly those that apply to breath alcohol tests, should be critically evaluated as to whether they offer any *significant* advancement in accuracy, reliability, impartiality, or efficiency.

One detrimental effect of this intensive review and study has been to add an undeserved measure of credibility to defense arguments and motions in driving under the influence (DUI) litigations. A second effect has been to lend credence to solving problems associated with assuring the accuracy and reliability of breath tests by adding expensive and unnecessary periph-

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eral devices and procedures that when critically examined are not the most cost-effective alternatives to assuring accuracy or reliability of chemical results. The net effect has been to saturate an already overburdened court system with unwarranted and, therefore, wasteful arguments. On the pretext that impartial justice to all individuals will be assured, the defense is too frequently allowed virtually unlimited opportunity to challenge the technical validity of chemical test methods and procedures whenever the defendant can afford to hire a defense expert.

To deal with this dilemma, it should first be determined who is responsible for ensuring that the many benefits that chemical test methods can make towards effective and efficient traffic law enforcement are not nullified by unwarranted defense challenges. In our system of justice this responsibility is divided among the legislature, prosecution, and the judiciary.

In California, the legislature had the foresight to recognize the technical complexities of designing and implementing chemical test laws for alcohol and other drugs. The legislature in 1969 enacted Chap. 5, Section 436.50-436.63 of Part I of Division 1 of the Health and Safety Code. This legislation, in conformance with the National Uniform Vehicle Code [*3*], mandated that the State Department of Health Services (DOHS) shall henceforth adopt and administer rules and regulations governing the operation of all laboratories engaged in the testing by, or for, law enforcement agencies of blood, urine, or tissue for the purposes of determining the concentration of ethyl alcohol in the blood of persons involved in traffic accidents or in traffic violations. This mandate also specified that tests of breath samples for alcohol shall be performed in accordance with these regulations. This law also specifies that:

> The rules and regulations shall be adopted only after the State Department of Health Services has consulted with at least one member of each of the following groups; district attorneys, public defenders, coroners, criminalists, pathologists, analytical chemists, and such other persons deemed by the Department to be qualified.

This mandate is important because it recognizes the diverse interests that must agree to cooperate in order that the intent of the law can be effectively implemented. As a result of this enabling legislation, the DOHS in 1970 formed a broadly based, standing Advisory Committee on Alcohol Determinations to assist the Department in formulating, implementing, and revising the regulations governing all forensic alcohol analysis conducted by, or for, California law enforcement agencies [*4*].

Because the issues involved are primarily technical, the legislature, prosecution, and judiciary, who enact the laws and establish implementation policy, must rely on competent, unbiased, scientific advisors to effectively deal with the many application and implementation issues connected with attaining the intended purpose for which chemical test laws have been enacted. Basically, the purpose of chemical test laws is to codify in the law "established scientific truths" to avoid repetitious testimony, and argument, in the majority of contested cases. The phrase "established scientific truths" is defined as: factual evidence that has been scientifically validated, published, and accepted by an overwhelming majority of peer scientists.

I do not wish to infer that "scientific truths" should not be subject to legal challenges, which is an essential element to assuring impartiality in the search for "legal truth" in our adversary system of justice. The concept of "scientific truth" as it relates to the role of the forensic scientist was succinctly explained by Seymour Pollock as follows:

> The adversary system was developed as a trial procedure for arriving at the truth of those matters about which information is inadequate, knowledge is incomplete, and interpretation is subject to influence from varying sources. It represents a technique for challenging the validity of data about which there could be disagreement; and it is used as a tool for exploring the level of confidence in an opinion that harbors a significant risk of error [*5*].

What I do infer, however, is that in the application of chemical test laws in the United States there has been widespread abuse of judicial discretion in allowing the defense community to challenge the technical validity of chemical test methods and procedures at the lowest court

level, directly thwarting the legislative intent of chemical test laws, which is to avoid unnecessary and repetitious challenges to the findings of fact. The irony of this widespread practice is that the lower court records upon which appellate decisions ultimately rely are too frequently established on the testimony of biased, unqualified, or inadequately challenged "expert" witnesses who in too many instances are motivated by monetary gain rather than the impartial search for the truth. The role of the scientist in the courtroom using breath alcohol tests as a microcosm of the science society interactions involved in presenting scientific truths was explored by Lovell [6]. Germain to the issues being discussed are the conclusions reached by Lovell which state, in part:

> To find those under this system who are not adversaries and who have a duty to remain objective, one must go to the legislature or, in the courtroom, to the judge and jury. To ensure that science is objective and fair, one can only go to the scientist themselves. If the particular encounter discussed has any value as a model for relations in general between science and society, it is this last feature that might earn first consideration. *The role intended for science is that of handmaiden to society, not prostitute.*

Forensic scientists can fulfill their responsibility towards achieving the legislative intent of chemical test laws by advocating the following basic principles when acting as an advisor, administrator, or expert witness on chemical test issues:

1. Recognize and accept the inherent biological variability that exists in any attempt to quantitate and interpret the effects of alcohol in human subjects.
2. Concede that no measurement is absolute but rather an approximation that can be expressed with degrees of confidence as to how close the measurements are to the theoretically "true" result. This inherent limitation can be overcome by using *methods* and *procedures* that have a demonstrated ability to quantitate alcohol in blood, breath, or urine specimens with an accuracy and precision of at least $\pm 5\%$ of the "true" value. This degree of accuracy in measurement was selected because it exceeds by an order of magnitude the ability to interpret what a blood alcohol concentration (BAC) means in terms of impairment in a specific subject [7].
3. Interpret the significance of chemical test results in an unbiased and objective manner and only to the extent that the interpretation can be supported by *"established scientific truths."*
4. Concede that chemical test methods or instruments for quantitating alcohol are not infallible because the humans who must apply the method or operate an instrument are not infallible. This inherent limitation can for all practical purposes be overcome by the application of *scientific test procedures* that incorporate repeated measurements of the value to be determined together with appropriate periodic calibration checks, controls, and blank samples, which when systematically applied effectively eliminate any reasonable possibility of systematic or random error.

It may appear from this list of what appears to be concessions that the application of chemical tests would be marginally effective in meeting their intended purpose. This undoubtedly would be true *unless* the forensic scientist advisor, administrator, or expert witness makes an effort to educate the prosecution and judiciary in the proper use, interpretation, and presentation of chemical tests as evidence.

The direct analysis of blood for alcohol and its interpretation in terms of impairment has been universally established and accepted in our judicial system and presents few practical problems for the analyst or the prosecutor as evidenced by the small number of contested cases involving direct blood analysis [8].

Urine specimens, though equal to a blood in terms of the quantitative analysis for alcohol in the specimen, may present some interpretative problems because, like breath, it is an *indirect* means of determining an equivalent BAC. This interpretative problem, however, is more theoretical than practical, provided a proper sampling protocol is followed. For example, collecting a urine sample 20 min to 1 h after voiding the bladder and using a urine-to-blood conversion

ratio of 1.3 : 1 is an accurate means of determining an equivalent BAC when applied within the context of the above four basic principles. This procedure is scientifically validated by the many hundreds of controlled urine/blood correlations as well as the many hundreds of *actual* case studies where both blood and urine samples have been analyzed and correlated [*9–16*].

Breath alcohol analysis, as currently applied, is an also indirect means of determining an equivalent BAC and generally utilizes rather sophisticated instrumentation. Therefore there is a dual opportunity for the defense to create doubt about the reliability and accuracy of an individual BAC determined through the analysis of a breath sample.

Doubts about the reliability and accuracy of breath alcohol analysis for determining an equivalent BAC can be effectively eliminated if the forensic alcohol expert applies the four basic principles enumerated above. Usual defense tactics applied to breath tests are: (1) misquoting scientific conclusion and (2) avoiding the practical significance of unspecified differences when quoting scientific articles or other experts' findings and opinions or both. Success in effectively rebutting these defense tactics requires the cooperation and understanding of the prosecutor and judge. The forensic scientists must be allowed to explain properly and adequately why such innuendos are erroneous and *do not* represent the current scientific opinion of the majority of forensic scientists actively engaged in forensic alcohol research or practice.

Defense tactics used to discredit the reliability and accuracy of breath alcohol tests as performed by an evidential breath tester to determine an equivalent BAC generally involve one or more of *five* issues:

(1) the conversion ratio used to convert a breath alcohol concentration (BrAC) to an equivalent blood alcohol concentration (BAC),

(2) specificity of the method to distinguish alcohol from other possible volatile compounds that could exist in breath samples,

(3) random error caused by intermittent malfunction or failure of an evidential breath test instrument,

(4) preservation of breath samples for referee analysis, and

(5) falsification of test results by a breath test operator.

Issue 1—Breath to Blood Alcohol Conversion Ratio

To deal with the breath to blood conversion ratio issue, we must first understand how the currently accepted "average" ratio of 2100 : 1 was established and, secondly, what is the *practical* significance of differences that could occur in an equivalent BAC obtained when this average ratio is applied to an individual subject.

The 2100 : 1 alveolar breath/blood conversion ratio has, since 1950, been the accepted standard for the calibration of all evidential breath testers (EBT) designed to analyze alveolar breath samples to determine an equivalent BAC. This ratio is based on Harger et al's [*17*] comprehensive studies of the partition of ethanol between air and water and blood and urine over a range of temperatures. One must not lose sight of the physics of the exchange of alcohol from liquid to a vapor. At a given temperature and pressure this ratio is a constant. Impeding the straightforward application of this constant to human breath tests are the temperature differences and changing alveolar breath sample quality that results from different breathing patterns. Temperatures can be affected by the manner in which the breath is taken. Several fast breaths just before blowing will cool the lungs giving a lower result, while holding the breath gives a longer opportunity for true equilibrium to be reached, giving a seemingly high result when using a 2100 : 1 ratio [*2*]. The effect of these human variables on the accuracy of a breath test can be largely mitigated and narrowed to reasonable confidence limits by requiring replicate breath samples that do not differ by more than 0.02%. Many hundreds of breath-to-blood ratio case studies and controlled correlation studies conducted since 1950 with EBT calibrated on the 2100 : 1 ratio have clearly shown that breath alcohol results underestimate the BAC determined in a simultaneous blood sample over 80% of the time, to be the same (that is, within $\pm 0.01\%$)

in about 15%, and to overestimate the BAC less than 5% of the time. Of particular significance is that the small number (<5%) of the breath results that overestimate the BAC are not more than 0.02% higher which is within the accepted experimental error of most contemporary breath test methods [*10,14,16-22*]. In light of the overwhelming scientific evidence, collected over the past 30 years, there is no practical significance to the arguments being perpetuated by the defense community regarding inaccuracies that may arise from a breath alcohol analysis used to determine an equivalent BAC. This is assuming, of course, that the obvious *negative* bias introduced by breath alcohol analysis (using 2100:1 calibration ratio) is of no significance to effective law enforcement.

Issue 2—Specificity

To deal with the issue of specificity in breath alcohol analysis, the court should understand to what degree breath test methods need to be alcohol (that is, ethyl alcohol) specific in order to measure accurately alcohol or other toxic substances or both that could exist in a human breath sample. This issue was, in California at least, ostensibly settled in the civil case of *Intoximeters Ins. v. Younger* [*23*]. After extensive expert testimony the court found there was no convincing evidence that the Intoxilyzer® breath alcohol instrument would respond at levels of measurement for substances that normally or reasonably would be expected to be found in persons arrested for DUI and thus the device met the standards of specificity fixed by California Administrative Code Title 17, Sec. 1220, 1 a[*4*]: "The method shall be capable of analysis of ethyl alcohol with a specificity which is adequate and appropriate for traffic law enforcement."

The scientific basis for this finding is that nonethyl alcohol substances that could be present in an expired breath of DUI suspects are so rare, or at such low concentrations as to not significantly affect the quantitation of ethyl alcohol in a breath sample [*24*]. This is because nonethyl alcohol substances that could exist in the blood of ambulatory subjects are generally much more toxic than ethyl alcohol. Those who have orally *ingested* intentionally, or accidentally, substances such as methyl alcohol, isopropyl alcohol, gasoline, paint thinner, or other industrial liquids generally become too ill, or comatose, and therefore are unlikely to drive a motor vehicle. The term orally *ingested* is important because it has been determined that even prolonged breathing or exposure to noxious atmospheric concentrations of ethanol, acetone, and other industrial solvents does not result in significant concentrations of these substances in the blood [*25,26*].

Defense attacks on specificity also include metabolically produced acetone, which can occur in the breath of persons with keto acidosis usually associated with very high blood sugar levels in poorly controlled diabetes or in persons on prolonged "starvation" diets. Extensive clinical and case studies have failed to demonstrate metabolic blood acetone levels in *ambulatory* diabetic subjects that would read at greater than 0.01% apparent alcohol even with such relatively "nonspecific" breath instrument as the Intoxilyzer Model 4011. A few rare cases of 0.02% to 0.03% "apparent" alcohol using the Intoxilyzer have been reported for alcohol-free subjects on a "starvation diet." Such cases are of no practical importance because the consumption of alcohol, a carbohydrate, would inhibit the further metabolic production of acetone; and even these low levels of blood acetone remaining from before the alcohol consumption would at least equal the effects of an equivalent blood alcohol concentration. What appears to be an inconsistency in the toxic effects of a given metabolic acetone level resulting from a "diabetic" as opposed to a "diet" or ingestion situation is a result of other metabolic substances and imbalances existing with the acetone in the diabetic situation that is *not* present when acetone is produced in a "diet" or ingestion situation [*6,24-29*].

Issue 3—Random Error in Breath Alcohol Test

Random error in breath testing can occur intermittently and undetected for a number of different causes. Several common causes would be: volatile substances in the mouth that are not

representative of a blood concentration, radio frequency or electrical interference, and failure to obtain an alveolar breath sample. The only truly effective way of eliminating the possibility of such random error is to apply a scientifically valid test procedure, such as replicate subject samples that must agree within an accepted degree of accuracy (that is, $\pm 0.01\%$) together with a blank sample before and after each subject sample. The common practice in many states of performing a simulator test contemporaneously with each subject tested while requiring only *one* subject sample per test *cannot* rule out the possibility of random error in a *subject test.* At best, this procedure only indicates that no random error occurred in the simulator tests. With only one subject sample, it is not possible to know, with a reasonable degree of certainty, that a random error did not occur in the subject test. The rationale of requiring replicate analysis for any quantitative procedure is universally accepted. There is no valid reason why it should not also be required to validate all breath tests [*7,30*].

Issue 4—Preservation of Breath Samples

The issue of preserving a breath sample for possible referee analysis has been raised as a "due process" legal argument: if a breath sample is collected as evidence, and it is possible to preserve that sample, then the subject has a *Constitutional right* to have the sample, or that portion of the sample not used by the prosecution, for the purposes of *referee analysis.*

The constitutional issues are not directly addressed here; however, the scientific issues involved in determining whether a breath sample analyzed by the prosecution *can be*, or *need be* preserved for *referee* analysis is the responsibility of the forensic scientist [*4,31*].

To deal logically with this issue, we must first define and distinguish several terms:

Referee analysis—an analysis performed by an independent laboratory to verify the accuracy of an analysis.

Evidential breath tester (EBT)—an instrument designed to determine *directly* from a test subject the concentration of alcohol in an expired breath sample and expressing the concentration as an equivalent blood alcohol level. In California, an EBT must be capable of meeting the standards of performance for forensic alcohol analysis as specified in Section 1221.2 of Title 17 [*4*].

Remote breath capture—A procedure whereby a breath sample(s) (or its functional equivalent) is collected in the field by a breath test operator for later analysis. In California, the combined procedures of sample capture and later analysis shall have the ability to meet the standards of performance set forth in Section 1221.2 which are the same as for an EBT [*4*].

It is advocated by knowledgeable forensic scientists that remote breath capture systems can and should serve a dual purpose: (1) as a substitute for EBT in remote and low demand locations where maintenance of an EBT may not be cost-effective and (2) to provide a preserved breath sample for *referee* analysis [*2*].

The first purpose of remote capture can fulfill a legitimate need provided the inherent limitations of existing remote capture systems can be tolerated. The inherent limitation of all remote capture systems is that, once a sample has been captured and held for later analysis, there is no way with the existing technology of determining that a "*loss*" of alcohol (the result of interest to the defense) was not the result of one or more types of undetectable error. Undetectable errors include: nonalveolar breath sampling, incomplete capture or absorption of alcohol, loss caused by evaporation, or alcohol degradation. It *cannot* therefore be concluded that when a preserved breath sample, or later analysis, gives a "lower" BAC than the BAC obtained with an EBT, that the EBT result is inaccurate. The inference drawn from a captured sample that an EBT result was not accurate is not a scientifically valid conclusion because the sources of error that could occur in a captured breath sample cannot be directly verified. Whereas, the results obtained with an EBT can be validated before, during, and after the subject is tested by the application of *test procedures* designed to eliminate any reasonable possibility of systematic or random error or by recourse to normal legal discovery procedure.

The *need be* part of the original issue question of whether a breath sample *can be* or *need be* preserved for referee analysis is primarily the responsibility of the judiciary to decide. However, the forensic scientist has the responsibility of providing competent and unbiased scientific rationale upon which an effective and just decision can be made.

If the judiciary should decide on legal grounds that, whenever a breath test is given, the subject is entitled to a "sample" for referee analysis and the judiciary cannot accept the scientific validity and adequacy of stand alone EBT *procedures*, then other scientifically valid alternatives should be considered before imposing a "preserved breath sample" requirement. A reasonable and scientifically valid alternative would be to advise the subject that if he chooses a breath test, it is not possible to preserve a breath sample for referee analysis, but that he may give a blood or urine sample which can be sent to the referee laboratory of his choice.

Issue 5—Falsification of Test by a Breath Test Operator

The possibility of intentional falsification of breath test results is an inherent weakness of *all* evidential breath testers (EBT), because the administration of a test ultimately depends on the competence and *honesty* of the breath test operator. Increased sophistication, which escalates the initial and ongoing maintenance cost of EBTs for the sole purpose of eliminating intentional falsifications, cannot be cost justified when it is realized that no amount of sophistication can completely eliminate this problem. At best, it can only increase the degree of difficulty that an operator must overcome in order to falsify a test result [*30*].

A scientifically administered and monitored chemical test program will do more towards eliminating the rare operator or analyst who is foolish enough to risk jeopardizing his integrity than will the addition of costly "tamper-proof" features to EBTs [*32,33*]

Conclusions

In current forensic science practice, direct blood and urine alcohol analysis present few application problems. Breath alcohol analysis is the focus of most forensic science controversy. This controversy stems primarily from the difference in rationale of how the scientist and legal counsel view the role and application of chemical tests in our adversary system of justice. Legal counsel prefers to deal in absolutes, yes or no answers, with no equivocal or gray areas. The scientist on the other hand recognizes that there are no absolutes and can rarely give simple "yes or no" answers without compromising scientific principles.

Most of the controversy and confusion surrounding the proper role and application of breath alcohol tests could be eliminated by the cooperation between the forensic scientist and the prosecutor in day-to-day trials in which the foundation for legal precedents, good or bad, is layed. The forensic scientists can fulfill their responsibility by adhering to ethical and scientific principles in the administration and application of *all* chemical tests for alcohol. The effects of such cooperation between scientist and prosecution would be greatly enhanced if the judiciary, at all levels, would defer to "established scientific truths" and technical authority as mandated by model chemical test laws [*3*] in making decisions regarding the admissibility of chemical test methods and procedures.

In general, and barring drugs other than alcohol also being present, the lower the %BAC, the less obvious will be the other elements of the case (such as driving performance, field sobriety tests, and behavior and demeanor) upon which a prosecutor can rely to provide a charge of DUI. Such circumstances emphasize the need for cooperation and understanding between the prosecutor and forensic scientists of the proper role and presentation of chemical test evidence in DUI cases.

Finally, if violations of chemical test laws are to be effectively prosecuted then the prosecutor must recognize and adopt the attitude that chemical test results are but one element of a case, and should not be the *only* substantive evidence to support a charge of DUI. This is particularly

true when the chemical test result is close to a statutory limit (that is, 0.10% BAC) where normal biological variations may indicate that the measurement, or its interpretation, may not apply to the specific individual being charged.

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