

# **Breath Tests for Alcohol Determination: Partition Ratio**

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## **I. SCIENTIFIC BASIS OF BREATH TESTS**

## **1. Introduction:**

In cases involving drunk driving, the prosecution has to prove that the defendant's blood alcohol concentration (BAC) at the time of the offense is at or above a statutory concentration. In the majority of jurisdictions it is 0.10% [i.e., 0.1 gram of alcohol per 100 milliliters of blood]. In some jurisdictions, it is 0.08%, *see People v. Ireland*, 39 Cal. Rptr. 2d. 870 (Cal. Ct. App. 1995). In this connection, there is an ongoing national debate to reduce this value to 0.08% nationwide. In order to provide proof of BAC it is necessary to obtain a suitable biological sample (i.e., blood, urine, expired air) from the defendant at the time of arrest. Determination of BAC by use of a breath test, is by far the most popular scientific test for drunk driving. The breath test involves the measurement of alcohol in an appropriate sample of breath, expired alveolar air. (Alveolar air is that part of the expired air, which is in equilibrium with blood; usually this is taken as the terminal portion of expired air. One likely reason for the high variability observed in partition ratios is the difficulty in obtaining true alveolar, or deep lung air for analysis). This breath alcohol concentration is then multiplied by a factor called the partition ratio to convert the concentration measured in the breath to the corresponding alcohol concentration in the blood. In most jurisdictions, a value of 2100 is used for this ratio by statutory mandate. However, this partition ratio of 2100 can differ from individual to individual or differ in a given individual from time to time. Therefore, while it is quite simple to perform, the use of breath tests to determine BAC suffers from a major and fundamental weakness in that it is an indirect method.

For that reason, the conversion (extrapolation) of the directly measured concentration of alcohol in the expired air to obtain its concentration in the blood has been the subject of much litigation. Understandably, this conversion is fraught with problems of variability (uncertainties) introduced by the theoretical assumptions underlying the method. As was pointed out by one of the leading researchers in this area, The most trying forensic difficulties were consequent to what now appears to some to be an error in policy made by the pioneers in breath testing. This was in deciding to calculate the blood concentration from a quantity of alcohol found in the breath. Mason & Dubowski, *Traffic & Chemical Testing in the United States: a Resume & Some Remaining Problems*, 20 Clinical Chemistry 126, 128 (1974). The following section will present the scientific basis for the statutory decision to select a partition ratio of 2100 and the variability, both inter-subject and intra-subject, to be expected in this ratio.

## **2. Basic assumptions:**

A direct correlation is assumed between the concentration of alcohol in the alveolar air and concentration of alcohol in the blood, more precisely, ethanol. This assumption is based on Henry's Law which states that, at constant temperature, the concentration of gas dissolved in a liquid is proportional to its concentration in the air directly above the liquid. Brent and Stiller, *Handling Drunk Driving Cases*, ' 7 (Breath Tests) (1985). As applied to determination of BACs, this means that the concentration in the expired alveolar air is directly proportional to the concentration in the blood (i.e., the greater concentration of alcohol in the blood, the greater its concentration in the expired alveolar air). It is at the alveoli, commonly called air sacs (of which there are about 700 million in an average adult), where exchange of gases occur between blood and the expired alveolar air. Alcohol is a volatile liquid and assumed to freely diffuse (i.e., readily pass) across the membranes of the alveoli. Due to the latter assumption, it is also assumed

that the exhaled alveolar air is in equilibrium with the blood. Equilibrium can be best explained as a condition where the ratio of concentrations of alcohol in blood and expired alveolar air has achieved a constant value. Therefore, in principle, its concentration in blood can be estimated by measuring its concentration in the expired alveolar air.

The commonly used partition-ratio of 2100 can be expressed as follows:

In principle, this ratio is determined by simultaneously (or as close to simultaneous as experimentally possible) measuring the concentration of alcohol in the blood and expired alveolar air of test subjects administered alcohol under controlled conditions. While values in the scientific literature for this ratio range from 1900 to 2400, an international panel chose, in 1972 Essentially by fiat, the currently accepted value of 2100. Brent, *supra* at 133.

### **3. Factors that affect the partition ratio.**

Some factors that affect the partition-ratio, such as the effect of temperature, may be obvious, even to a non-scientist. There are others that are not so apparent. These factors can either increase or decrease the actual BAC.

*a. Effect of Temperature:* The widely used partition blood-to-air partition ratio of 2100 is based on a normal body temperature of 98.6 °F. A higher body temperature of the individual will overestimate the actual BAC because of the higher volatility (or vapor pressure) of liquids like alcohol at a higher temperature. An elevation in body temperature of 1 °C (1.8 °F) results in a 7% higher value in the result. Therefore, a person with a body temperature of 100.4 °F and with an actual blood alcohol of 0.0935 % will register a value of 0.10 % by the breath test. As can be seen from this hypothetical example, a small difference in body temperature can make the difference of guilt or innocence of drunk driving in defendants with a BAC close to the legal limit. This widely accepted ratio is also based on the assumption that the average temperature of exhaled air is 93.2° F.

*b. Atmospheric Pressure:* There is little evidence to support the belief that the partition ratio is affected by atmospheric (barometric) pressure. Breathalyzer tests conducted at altitudes of 5000 feet and 10000 feet essentially gave the same results. This is expected based on scientific principles of gases.

*c. Cellular Composition of Blood:* Blood contains suspended cells (e.g. red and white cells) and proteins, and is therefore only a partial liquid. The partition ratio of 2100 is based on a average hematocrit (the cell volume of blood) of 47%; hematocrit values range from 42 to 52 % in males and 37 to 47 % in females. Therefore, a person with a lower hematocrit will have falsely elevated blood alcohol based on a breath test; this variability has been estimated to be relatively small, ranging from - 2 to + 5 %.

Since alcohol freely diffuses into cells but not into cellular membranes, the subtle point to be aware of is the variability in volume of the cell debris (i.e. volume of cell membranes after cells are analyzed), and not the actual hematocrit that is responsible for the reported variability. Understandably, a higher hematocrit value represents a higher value of cell debris. The mean

value from several studies show that debris can account for about 16% of the volume of blood. For example, 0.119 mg % (in serum) is equivalent to 0.10% of BAC. Fitzgerald and Hume, *Intoxication Test Evidence: Criminal and Civil*, ' 4:26 at 152 (1987).

d. Physical Activity and hyperventilation: Exercise can underestimate blood alcohol values. In one study BACs of subjects before and after running up a flight of stairs decreased 11 to 14 % after one trip and 22-25 % after two such trips. In a another study, a 15% decrease in blood alcohol was reported in subjects following vigorous exercise or hyperventilation.

e. Changes in water content of expired air: Water, present in the form of vapor, in expired air will condense into the liquid form with a lowering of temperature. Air exhaled into the tubes of a breath test device, such as the Breathalyzer, is assumed to be saturated with water at about 93.2<sup>0</sup> F . Decreases in this temperature can result in an underestimation of reported BAC due to condensation of water and the subsequent removal of alcohol from the expired air. One study showed that when the mouthpiece of the breath test instrument was kept at 23<sup>0</sup>C, there was an average decrease in temperature of exhaled air by 1.6<sup>0</sup>C.

f. Radio Frequency Interference (RFI): Andre Moenssens, et al., *Scientific Evidence in Civil and Criminal Cases* ' 3.09 at 204 (4th ed. 1995). This interference describes the effect of an electronic instrument on a radio wave or current that it is not designed to pick up. If a particular Breathalyzer as an electronic instrument were susceptible to RFI, then the measurement of light distance obtained when the operator balances the meter might not be an accurate indication of the amount of alcohol in the breath sample. Instead, the light distance might reflect, in part, a deflection in the meter needle caused by a stray current induced by radio waves in the surrounding environment

## **II. Variability of Partition Ratio To Challenge Breath Test Results**

Breath test results have been challenged based on the variability of the partition ratio on the following grounds: (1) general evidence of variability in this ratio and (2) specific evidence that defendant's ratio differed from the mandatory value of 2100. ?

### **4. Admissibility of General Evidence of Variability**

#### **a. Admissibility and Inadmissibility**

Court decisions generally indicate that testimony challenging the reliability of breath tests is assumed admissible. Therefore, only a small number of cases have specifically addressed these issues.

A 1983 court ruled that a defendant may offer expert testimony to show that for one reason or another the test results of 0.10% or higher do not prove beyond a reasonable doubt that the level at the time of driving was in excess of that proscribed. *Fuening v. Super. Ct. of Maricopa*, 680 P.2d 121, (Ariz.1983). The defendant was booked for Driving while under the influence, when his performance on filed sobriety tests was unsatisfactory. Defendant ' s BAC tested at 0.11% using a breath (Intoxilyzer) test. The defendant was charged with violating a per se statute that

states It is unlawful and punishable for any person to drive or be in actual physical control of any vehicle while there is 0.10 per cent or more by weight of alcohol in the person's blood. *Fuening*, 680 P.2d at 124.

During trial, the defendant's expert witness, a professor of analytical chemistry, testified that Intoxilyzer results are subject to distinct type of errors: (1) an inherent error of 10% [i.e., a reported value of 0.10 % in the BAC could be either between 0.09 and 0.11 %] resulting from equipment calibration and test administration and (2) a 30% error resulting from the use of the standard 2100:1 partition ratio which varies as much as 30% between individuals. The defense argued that, in view of these uncertainties associated with the Intoxilyzer test, violation of the applicable could not be established beyond a reasonable doubt. The jury found the defendant guilty after six minutes of deliberation because the defendant Smelled strongly of alcohol, was unable to stand without help, suffered nausea, dizziness or other symptoms of intoxication. *Fuening*, 680 P.2d at 130.

While the appeals court did not directly deal with the defendant's arguments regarding the errors associated with measurement and general variability of the partition ratio. Instead, they reversed the trial court decision on the grounds that the police department was not participating, as mandated by statute, in a quality assurance program approved by the Department of Health Sciences.

The ruling has a bearing on breath test admissibility in court, because of the importance of conducting this test in the prescribed manner was emphasized by the Court. The court stressed that evidence on the general variability of the breath test is admissible given the fact that this ratio can also vary within the same individual. *People v. McDonald*, 254 Cal. Rptr. 384 (Cal. Ct. App. 1988). The defendant's BAC using a breath test administered an hour and ten minutes after the arrest for driving erratically was 0.13. The expert witness for the prosecution testified, inter alia, that (1) an individual's partition ratio is constant but can be altered by illness, medication and environmental factors such as air pollution and (2) the partition ratio can vary between 1550:1 and 2700:1 between individuals. The expert for the defense agreed that the partition ratio is subject to intra-subject variability and (presumably because of this) it is speculative to conclude that the same ratio existed in a given individual at two different times. He also testified that it is expensive to determine the variability in the partition ratio of a given individual. He testified that the breath test is accurate 85 percent of the time.

The jury was instructed as follows: [t]he defendant is presumed to have a 2100 to 1 breath to blood partition ratio unless he presents evidence as to his personal ratio which raises a reasonable doubt that the 2100 to 1 ratio is not valid for him. General evidence of such possibility of error in the partition ratio will not suffice to rebut this presumption. *McDonald*, 254 Cal. Rptr. at 386. The court refused to include a related instruction by the defense: [y]ou are instructed that the law of this state requires that the blood alcohol level be reported to you as 2100 times the breath alcohol level which was measured. The law does not require that you accept that reported blood alcohol as correct. It is an expert opinion, and you may examine the facts it is based on before deciding whether to accept it or reject it. *McDonald*, 254 Cal. Rptr. at 387.

The defendant was found guilty. On appeal, the court ruled the trial court erred in instructing the jury that it should presume that the defendant had a partition ratio of 2100:1 unless he presented evidence to the contrary. Basically, the instruction assumes a constancy of the partition ratio and supports a factual matter which is in doubt. The resolution of matters of fact is to be decided by the jury.

In *People v Lepine*, 263 Cal. Rptr. 543 (Cal. Ct. App.), it was ruled that the defense has the right to cross examine prosecution's expert testimony on the partition ratio and introduce evidence concerning the general variability of the partition ratio. Defendant was found to have a BAC of 0.13 per cent based on a breath test, which used a partition ratio of 2100:1, set forth by statute. The defense intended to challenge the partition ratio by cross-examining the expert witness for the prosecution and presenting its own expert witness. As evidence, the defense produced testimony from its expert that (1) the ratio of 2100:1 is not only different between individual's but also varies within a given individual from one time to another, (2) several individual and environmental factors such as lung temperature and air humidity affect the readings, and (3) it would cost about \$6000 to determine the variability of the ratio in a particular individual. The prosecution objected that before the validity of the ratio can be challenged, the defense must provide evidence that the defendant's ratio at the time the breath sample was taken was different from that set by the state. In addition, such a general attack was irrelevant, speculative and potentially confusing.

The trial court agreed and refused to allow cross-examination of the prosecution's expert witness or introduction of evidence concerning the general variability of the partition ratio. The appeals court held that the proffered evidence was admissible and ruled that the trial court erred in applying what is commonly called the rule of convenience, which states that when the exonerating fact was peculiarly within the defendant's control, the burden was on the defendant to present [such] evidence. Applying this rule here, it would be the defendant's responsibility to provide evidence to the partition ratio applicable to her. The appeals court noted that the issue of intrasubject variability of the partition ratio had not been raised in previous cases using the rule of convenience. See *People v. Pritchard*, 209 Cal. Rptr. 314 (Cal. Ct. App. 1984); *People v. Gineris*, 209 Cal. Rptr. 317 (Cal. Ct. App. 1984). In the present case, the expert for the defense raised the existence of such variability and therefore, it is practically impossible to know what the defendant's partition ratio was at the time of the breath test. Therefore, the rule of convenience is inapplicable because the defendant did not have a substantially greater ability to establish the exonerating fact than the prosecution. *McDonald*, 254 Cal. Rptr. at 388.

**The remaining cases depicting how various jurisdictions treat the partition ratio, have been extensively edited to reduce the length of this article.**

A similar reasoning was used in *People v. Cortes*, 263 Cal. Rptr. 113 (Cal. Ct. App. 1989), where the court ruled that since the partition ratio is not an element of the crime, the prosecution is not required to prove the defendant's ratio as such. However, when the conviction of a charge depends on the accuracy of a breath test, the burden of proof is placed on the prosecution. Therefore, the trial court conviction was reversed because the jury instructions inappropriately created a judicial presumption of accuracy with respect to the test results.

In *People v Thompson*, 265 Cal. Rptr. 105 (Cal. Ct. App. 1989) (citing *Pritchard*, 209 Cal. Rptr. 314), another California case, the trial court ruled that no evidence, either by the prosecution or the defense, could be introduced that was outside the 10% error rate (i.e., 1700:1 to 2300:1) set for the variability of the partition ratio, since the ratio of 2100:1 used in the statute was derived from this case. However, the appeals court reversed the trial court conviction because expert testimony was not allowed to introduce evidence that (1) the partition ratio varies within the same individual at different times, and therefore it is not possible to extrapolate the partition ratio measured in an individual from one point in time to another point in time; and (2) the partition ratio varied from 600:1 to 3000:1 in the general population. The court further ruled that general evidence of partition ratio variability should not be excluded and it was time to abandon the rule of convenience as enunciated in *Pritchard*. *Id.*

## **5. Specific Evidence of Variability**

### a. Admissibility

Breath test results can be challenged using a defendant's own partition ratio. *City of Viroqua v. Mills*, 143 Wis. 2d 892, 421 NW2d 117, (unpublished disposition 1988). A defendant's breath test showed the BAC was 0.121 grams of alcohol per 210 liters of his breath. The statute provides "no person may operate a motor vehicle while [t]he person has a BAC of 0.1% or more by weight of alcohol in that person's blood or 0.1 grams or more of alcohol in 210 liters of the person's breath." Here the trial court ruled the expert testimony inadmissible --that this defendant's BAC would be 12% less than found by the breath test, and that his partition ratio is only 1899:1, as opposed to the statutory value of 2100:1. The appeals court reversed, ruling that the testimony should have been allowed because it was competent evidence bearing on the question of whether he was under the influence or had a BAC of 0.1% by weight.

### b. Inadmissibility

Many jurisdictions circumvented the need for the partition ratios by amending their statutes to include an offensive level of concentration of alcohol measured in breath.

The Supreme Court of California affirmed on appeal the inadmissibility of testimony of an individual's partition ratio, especially when the defendant exhibited clear signs of alcohol. Here the court looked to legislative intent to discourage drunken driving therefore a conviction based on alcohol measured by breath as amended by statute would stand. *People v. Bransford*, 884 P.2d 70 (Cal. 1995).

Likewise, a Georgia appeals court affirmed a trial court ruling that excluded testimony of a defendant's partition ratio (the day before trial he had a ratio of 1680:1, less than the state standard of 2100:1) when the defendant exhibited other visible signs of intoxication. *Burks v. State*, 394 S.E.2d 136, 137 (Ga. Ct. App. 1990). Here defendant had a strong odor of alcohol on his breath, blood shot eyes, and was also weaving slightly as he stood. Therefore, a conviction based on alcohol measured by breath as amended by statute would stand.

In yet another California case, the defendant chose the breath test versus a blood or urine test to determine his alcohol level. *See Ireland*, 39 Cal. Rptr. 2d. 870 (Cal. Ct. App. 1995). Here, an expert witness testified that the statutory partition ratio of 2100:1 would be overestimated during the absorptive phase and underestimated in the post absorptive phase, he also testified that the defendant's breath alcohol was determined to be 1329:1 during the absorptive phase. (Absorptive phase refers to the time when alcohol is being absorbed from the gastrointestinal tract. Post absorptive phase refers to the time when absorption is complete). However, the expert could not tell what this ratio was at the time of the defendant's arrest. Again, the court looked to legislative intent, the visible signs of intoxication exhibited by the defendant and the fact that the conditions under which the defendant's partition ratio was determined was different to those at the time of his arrest. Therefore, a conviction based on alcohol measured by breath as amended by statute would stand.

The evolution of court decisions on the admissibility of variability of the partition ratio is quite interesting. Without question, expert scientific testimony has had an impact. California courts, at first ruled that, unless there is evidence to the contrary, an individual's partition ratio is to be assumed to be 2100. *Pritchard*, 209 Cal. Rptr. 314 (Cal. Ct. App. 1984). This was generally referred to as the rule of convenience. While these courts were aware of the general variability of the partition ratio, expert testimony indicated that this ratio was a specific, fixed characteristic of an individual. Alternatively, testimony was not introduced that this ratio was not a fixed characteristic of the individual. Therefore, the rationale for the rule of convenience was that the burden of providing such proof depended on the defendant who was uniquely capable of producing such data. With the introduction of expert testimony that this ratio was not fixed in a given individual, and could change from time to time in the same individual, California courts rejected the rule of convenience. *See McDonald*, 254 Cal. Rptr. 384 (Cal. Ct. App. 1988). The applicability of the 2100 to 1 ratio became a matter of fact to be decided by the jury based on the total evidence presented at trial.

The court, applying the rule of convenience, held that the burden of proof of an individual's variability in the partition ratio was up to the defendant; in the absence of such proof, the partition ratio of 2100:1 shall apply. Defendant was convicted of driving with a blood alcohol of 0.10% or more; his test results were 0.11% and 0.12% based on the intoxilyzer tests. He appealed on the basis that the evidence presented at trial was insufficient to warrant conviction. The expert testimony presented included, inter alia, that there could be a 10% variability with the partition ratio of 2100:1 in the general population associated and that 95% of people fell within 10% of this ratio (thus establishing a range of 1900:1 to 2300:1 for the general population). The defendant argues that if this margin of error is applied to the lower of the two readings (i.e., 0.11%), the corrected value will be less than 0.10%. Therefore, he would not be guilty because the Vehicle code section 23152, subdivision (b) states "the People must prove beyond a reasonable doubt that at the time he was driving [the defendant's] blood alcohol exceeded 0.10 percent." *See Pritchard*, 209 Cal. Rptr. at 315 (Cal. Ct. App. 1984). The issue the appeal's court faced was that, in the absence of any evidence about the appellant's partition ratio, whether this 10% error should be applied to his intoxilyzer test results. The court decided that the burden of establishing the partition ratio applicable to the appellant was upon him because the individual partition ratio is an individual physical characteristic of the defendant, and presumably can only be obtained through means of physical tests upon him. The defendant is in control of this



information or at least of access to it. The court noted that the defendant could have avoided this problem by opting to take the direct blood test allowed by Vehicle Code section 13353; the blood test does not use the partition ratio. The holding in *Pritchard* is not followed anymore in California. If amendments to statutory language that include breath alcohol concentrations are adopted in other jurisdictions, variability in partition ratio as a defense may either become inadmissible or irrelevant.

### III. UNCONSTITUTIONALITY OF PER SE STATUES

#### 6. Unconstitutionality of per se statues

##### a Irrebuttable presumption

Courts have held that use of a breath test to prove alcohol concentration in the breath or blood of the defendant did not raise the issue of irrebuttable presumption. Breath tests are admissible and the accuracy of the test may be challenged on any ground *Fuening* 680 P.2d 121. Here defendant was convicted with a BAC of 0.11%, a per se violation of a statute that made it an offense to drive with a BAC if more than 0.10 percent. Expert testimony was allowed as to the general variability of the partition ratio and error resulting from time elapsed between time of arrest and time of test. On appeal, the defendant argued that finding guilt beyond a reasonable doubt on the basis of the test results, which are subject to scientific inaccuracies, creates an irrebuttable presumption of guilt. Such presumption is in violation of the Fourteenth Amendment, which requires that the state prove each and every element of a crime beyond a reasonable doubt. The court conceded that there was some validity to this argument. However, it found it unnecessary to rule on the question, because the defendant could challenge the accuracy of the breath test on any relevant grounds. Furthermore, [c]onviction is possible only when the jury finds beyond a reasonable doubt that the defendant ' s BAC level at the time of driving was 0.10% or more, not simply that the tests results were 0.10% or greater." *Id.* at 127.?In *People v. Capporelli* 502 N.E.2d 11 (Ill. Ct. App. 1986), the court held that a per se statute for drunk driving was not unconstitutional in spite of variability in the partition ratio. Convicted of driving with a BAC of 0.11% in excess of the statutory provision of 0.10%, he appeals on the basis that the irrebuttable presumption created by the use of a fixed partition ratio (i.e., 2100:1), to be determined by blood, was unconstitutional. The court found no merit to his claim and concluded that in spite of error associated with the test, based on the evidence presented by both the prosecution and the defense, that there was adequate scientific basis for methods approved by the legislature.

The court ruled that a conviction for drunk driving cannot be reversed on the argument that breath test results assumes that all individuals have a partition ratio of 2100:1. *State v. Allen* 802 P.2d 690 (Or. Ct. App. 1990). On appeal the defendant argues that the per se statue creates an unconstitutional presumption, because the state does not have to prove that the defendant ' s blood alcohol was 0.08 % or higher. The Court disagrees on the basis that the state is required by the statue to prove that the blood alcohol level is 0.08% or higher based on blood or breath tests.

In *State v. McCarty* 434 N.W.2d 67 (S.D. 1988), the court ruled that a statutory declaration that the partition ratio is 2100:1 did not create an unconstitutional irrebuttable presumption. The

defendant had a BAC of 0.14% based on a breath test. At the trial, the defendant raised issues concerning the reliability of using a partition ratio of 2100. At trial, the jury was instructed in language identical to statutory construction that BAC shall be based on either alcohol concentration in blood or breath. The court acknowledged that this ratio can vary from 1142 to 1 to 3478 to 1; it even quoted an expert on the artificial rigidity of mandating a partition ratio of 2100 to 1. While admitting that the jury instruction was improper, the court said that it was cured by another instruction which stated that presumptions created by statute are inconclusive, and must be considered a part of the total evidence presented at trial. Therefore, there was no irrebuttable presumption of guilt by the state.

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