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ALCOHOL AND OTHER DRUGS IN WISCONSIN DRIVERS: THE LABORATORY PERSPECTIVE

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INTRODUCTION

A driver's risk of a traffic accident rises exponentially with increasing blood alcohol levels.[1] In 1984 forty-five percent of all Wisconsin driver fatalities had blood alcohol concentrations equal to or greater than 0.10% by weight.[2] The incidence of alcohol in boating, snowmobile, motorcycle and pedestrian fatalities is similarly high.[3] The percentage has remained fairly constant, around fifty-five percent, in male driver fatalities over the years, but has increased in female driver fatalities, from fifteen to eighteen percent in the early 1970s to over thirty percent in the 1980s, except for the years 1978 and 1984.[4]

The average blood alcohol concentration in Wisconsin drivers arrested for driving under the influence is 0.17% by weight,[5] a number which has decreased slightly over the years.[6] Although textbooks describe blood alcohol levels in excess of 0.25% by weight as consistent with coma or stupor,[7] about ten percent of driver's samples tested by the Wisconsin State Laboratory of Hygiene (SLH) have levels at least this high. Occasionally, the SLH has tested drivers with levels in

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1. *See* Eckardt, *Health Hazards Associated with Alcohol Consumption*, 246 J.A.M.A. 648 (1981).

2. WISCONSIN DEPARTMENT OF HEALTH AND SOCIAL SERVICES — DIVISION OF HEALTH, 1984 BLOOD ALCOHOL TESTING FOR MOTOR VEHICLE DEATHS: WISCONSIN 9 (1984).

3. *Id.* at 8.

4. *Id.* at 9.

5. Interview with Robert E. Kindschi, Director, Bureau of Driver Licensing, Wisconsin Department of Transportation (Mar. 29, 1984).

6. *Id.*

7. *See, e.g.*, S. KAYE, HANDBOOK OF EMERGENCY TOXICOLOGY 178 (2d ed. 1961).

excess of .40% by weight. This level clearly reflects tolerance to alcohol.[8]

The most common drug other than alcohol found in Wisconsin drivers is diazepam (Valium).[9] The next most common drug is cocaine and its metabolite, benzoyl ecogonine.[10] Barbituates, as a class, are present as frequently as cocaine. Some drivers have combinations of substantial levels of multiple drugs.[11]

Two facts suggest that Wisconsin is not a leader in laws governing motor vehicle offenses involving alcohol or other drugs. First, in 1973, Wisconsin was the forty-eighth state to revise the statutory definition of driving while under the influence from 0.15% or more by weight of alcohol in a person's blood to 0.10% by weight.[12] Second, Wisconsin is among only a few states that have not yet raised the legal drinking age to twenty-one.[13] From the laboratory's viewpoint, however, Wisconsin's laws are among the nation's most comprehensive and coherent.

The purpose of this article is to provide members of the bar with a summary description of the laboratory's perspective on significant Wisconsin laws pertaining to the use of alcohol and other drugs by drivers. Section I of this article addresses specific features of Wisconsin law pertaining to motor vehicle offenses involving the use of alcohol and controlled substances. Section II describes Wisconsin state agencies with responsibilities relating to tests for driving under the influence of alcohol and other drugs. Section III describes the pharmacology of alcohol, and other drugs, and the effects of alcohol and other drugs on driver performance.

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8. Tolerance is the ability to resist the expected effect of a medication; tolerance occurs after prolonged use or habituation to a drug.

9. Statistics compiled by the State Laboratory of Hygiene, Toxicology Section (as of Dec. 17, 1985).

10. *Id.*

11. *Id.*

12. Prima facie evidence of "driving under the influence" is defined at WIS. STAT. § 885.235(1)(c) (1983-84). Previous to August 17, 1973, this section required a reading of at least 0.15% by weight of alcohol in a person's blood to establish prima facie evidence of "driving under the influence." The statute was amended in 1973 to require a showing of only 0.10% by weight to establish a prima facie case. 1973 Wis. Laws 102.

13. In Wisconsin, the minimum legal drinking age is 19. WIS. STAT. § 125.02(8m) (1983-84).

I. WISCONSIN LAW GOVERNING MOTOR VEHICLE OFFENSES INVOLVING THE USE OF ALCOHOL OR CONTROLLED SUBSTANCES

Wisconsin law permits one or more tests of an arrested driver's breath, blood or urine.[14] The breath test gives both the driver and the arresting agency a quantitative alcohol result fairly quickly, permitting an informed decision about whether to detain the driver. A breath test is generally the first test offered, especially in areas where it is inconvenient to obtain a blood sample because the local hospital is some distance away, has limited services at night, or prefers not to work with drinking drivers, law enforcement officers, and matters with a potential for legal involvement.

The blood test should be the first choice if the use of drugs other than alcohol is suspected or if circumstances make the breath test not the test of choice (e.g. a severely injured or unconscious driver). The provision for "tests"[15] permits a blood test after a breath test if the breath alcohol levels seem too low to explain the impaired driving or if there is a problem with the initial test. It is not possible to detect controlled substances in a breath sample.

Wisconsin's law regarding driving under the influence of an intoxicant has recently been improved by several changes. The previous language, introduced in 1971, prohibited driving under the influence of intoxicants or controlled substances.[16] It soon became apparent that many drivers were under the influence of a combination of alcohol and controlled substances, no one of which was present in sufficient concentration to explain the impairment observed. In 1981 the law was changed to prohibit driving "under the influence of an intoxicant or a controlled substance or the combination of an intoxicant and a controlled substance."[17] In 1983 the legislature added the language "or . . . any other drug to a degree which

14. WIS. STAT. § 343.305(1)(1983-84).

Blood tests measure blood alcohol concentration, a percentage by weight of alcohol in a person's blood. Breath tests measure breath alcohol concentration, a percentage by weight of alcohol in 210 liters of a person's breath. Urine tests measure urine alcohol concentration, a percentage by weight of alcohol in a person's urine.

15. *Id.*

16. 1971 Wis. Laws 219, § 21 (codified at WIS. STAT. § 346.63 (1)(a)).

17. 1981 Wis. Laws 20, § 1598 (codified at WIS. STAT. § 346.63(1)(a)).

renders him or her incapable of safely driving or under the combined influence of an intoxicant and any other drug to a degree which renders him or her incapable of safely driving . . . ."[18] This statutory modification is an important and useful provision derived from the Uniform Motor Vehicle Code.[19] The comprehensive statute covers drugs such as the tricyclic antidepressants amitriptyline and imipramine which, because of their low abuse potential, are not likely to become classified as controlled substances. Nevertheless, these drugs are fully capable of thoroughly impairing a driver's performance when present in sufficient concentrations. Because the state must demonstrate that a driver is rendered incapable of safely driving,[20] drivers are protected against prosecution for driving under the influence of normal doses of drugs not known to impair driving, such as insulin, aspirin, most antibiotics and vitamins.

Wisconsin law also prohibits driving under the influence of "intoxicants."[21] This provision has been applied to the inhalation of non-drug hydrocarbons (solvents) by a driver who appeared intoxicated, failed to pass the field sobriety tests and had measureable blood levels of hydrocarbons, which are central nervous system depressants.[22]

Another notable feature of Wisconsin's law is the statutory definition of the meaning of breath and urine alcohol concentrations.[23] The statute defines the concentration of alcohol in the blood as three-fourths of the concentration of alcohol in the urine.[24] This definition eliminates the need to determine the individual ratio for each driver and is based on the predictable relationship between the water content of blood and urine.[25]

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18. 1983 Wis. Laws 459, § 12 (to be codified at WIS. STAT. § 346.63(1)(a)).

19. UNIF. VEH. CODE § 11-902.1 (1979).

20. *See* WIS. STAT. § 346.63(1)(a) (1983-84).

21. *Id.*

22. State v. Kinkaid, No. 83 CT 493 (Jefferson County Cir. Ct. Dec. 16, 1983).

23. WIS. STAT. § 885.235 (1983-84).

24. WIS. STAT. § 885.235(2) (1983-84).

25. *See* Biasotti & Valentine, *Blood Alcohol Concentration Determined from Urine Samples as a Practical Equivalent or Alternative to Blood and Breath Alcohol Tests*, 30 J. FORENSIC SCI. 194 (1985).

A recent change in the law also defines statutory violations in terms of breath alcohol concentrations.[26] Today, the statute states that "0.1 grams of alcohol per 210 liters of breath is prima facie evidence that he or she was under the influence of an intoxicant and is prima facie evidence that he or she had a blood alcohol concentration of 0.1% or more."[27] Not only does this new wording eliminate any need to establish an individual's personal blood/breath ratio; it goes beyond the concept of defining a ratio by statute to defining the offense in terms of the actual measured breath alcohol concentration.

II. WISCONSIN STATE AGENCIES WITH RESPONSIBILITIES RELATING TO TESTS FOR ALCOHOL AND OTHER DRUGS

A. State Agencies

The Wisconsin Department of Transportation (DOT) maintains driver records and carries out licensing sanctions against convicted drinking drivers.[28] The DOT Office for Highway Safety Technical Committee on Alcohol and Other Drugs and Driving oversees distribution of federal seed money for projects to address the drinking driver problem. Responsibility for the state's breath testing programs is in the State Patrol division of DOT.[29] The program provides local law enforcement agencies with breath testing instruments, instrument maintenance, operator training and assistance with court testimony, if needed.[30]

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26. 1981 Wis. Laws 20, § 1816c (codified at WIS. STAT. § 885.235(1)).

27. WIS. STAT. § 885.235(1)(c) (1983-84).

28. *See* WIS. STAT. § 343.31 (1983-84).

29. With respect to the drinking driver problem, the DOT's responsibilities are set forth in WIS. STAT. § 110.07 (1983-84) and WIS. ADMIN. CODE § [TRANS.] 311 (1985).

30. *See* WIS. STAT. § 343.305(10)(b)(1983-84). *See also* WIS. ADMIN. CODE §§ [TRANS.] 311.11(1), 311.08 (1985). Forty hours of training, including instrumentation theory and practice and the pharmacology and physiology of alcohol and relevant law, have been required for operator certification on the Smith and Wesson Breathalyzer 900 and 900A. By early 1986 all breath testing instruments in Wisconsin will be replaced by the Federal Signal Intoxilyzer 5000, which uses the infra-red principle of analysis rather than the chemical reaction used by the breathalyzers. Intoxilyzers have the advantage of being able to test for and measure the steady plateau of breath alcohol concentration produced when the subject is exhaling deep alveolar air. This feature prevents readings being taken on inadequate samples or samples containing spurious alcohol from the mouth due to eructation. These microprocessor controlled instruments have a rapid, automated test sequence which requires no operator interac-

The Department of Health and Social Services (DHSS) is responsible for issuing annual permits to persons who perform blood and urine alcohol analysis under Wisconsin law.[31] DHSS also approves laboratories performing blood and urine alcohol analysis and develops and administers a program for regular monitoring of the laboratories.[32] In 1985 there were twenty approved laboratories. The list is available from DHSS and is provided to all enforcement agencies in the state. The DHSS Department of Health, Bureau of Health Statistics compiles data on blood alcohol levels in driving, pedestrian and boating fatalities. Each year they publish a comprehensive report entitled *Blood Alcohol Testing for Motor Vehicle Deaths*.

The University of Wisconsin State Laboratory of Hygiene (SLH or "Hygiene Lab") is the state's laboratory for public and environmental health. The toxicology section of SLH is one of twenty approved laboratories for blood and urine alcohol analyses. It is one of two laboratories approved to analyze the blood samples which coroners are required to submit for every Wisconsin driver or pedestrian fatality sixteen years of age or older who dies within six hours of the accident.[33] In addition, the SLH is the only laboratory approved for alcohol testing in cases of snowmobiling and boating fatalities.[34]

The great majority of blood and urine samples from Wisconsin drivers—about 8,000 a year—are sent to the SLH for alcohol analysis. The SLH is the only laboratory in the state currently providing analyses for drugs and intoxicants other than alcohol in arrested drivers. Other SLH responsibilities include approving methodology for blood and urine alcohol analyses, providing kits for blood and urine specimen collection, and specifying methods for urine specimen collection.

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tion other than to type in information regarding the subject and citation. Operators will receive only twenty-four hours of training on the Intoxilyzer, a simpler instrument to operate than the breathalyzer. All instruments are subject to periodic inspection and maintenance, which is done by a DOT "Area Coordinator" who is responsible for all instruments in a given area of the state. Breath test operators are recertified every two years upon demonstrating continuing proficiency in conducting breath tests.

31. *See* WIS. STAT. § 343.305(10)(a)(1983-84).

32. *Id.*

33. *See* WIS. STAT. § 346.71 (1983-84).

34. *See* WIS. STATS. §§ 30.67, 350.155 (1983-84).

SLH works closely with the other twenty approved laboratories, advising on methodology and conducting workshops to keep laboratory employees informed of changes in the laws, discussing issues related to specimen collection, preservation, analysis and interpretation, and helping alcohol analysts and specimen collectors prepare for the experience of testifying in court. SLH assists DOT in answering questions about breath testing chemistry and physiological aspects of breath testing.[35]

B. Specimen Collection, Storage and Analysis

Blood specimen collection kits are provided by the SLH to state law enforcement officers. These kits contain evacuated blood collection tubes with sodium fluoride and oxalate preservatives and non-alcoholic benzalkonium chloride swabs for cleansing the arm.[36] Specimens collected using the preservative are stable for weeks at room temperature and months in the refrigerator.[37] Experiments demonstrate that even without the preservative blood specimens from living subjects are stable (no change in alcohol concentration) for at least fourteen days at room temperature.[38]

SLH toxicologists use gas chromatography to analyze specimens. Gas chromatography separates and identifies any alcohols and certain other hydrocarbons which may be present such as ethanol (beverage alcohol), methanol (wood alco-

35. Since 1981, the position of "breath testing specialist" at SLH has been held by Patrick Harding. Mr. Harding has been active in conducting research and testifying about the question of Breathalyzer ampoule preservation, evaluating the new infra-red breath testing instruments, and dealing with questions about the effects of certain medications and environmental chemicals on breath test results. He has also conducted training for DOT chemical test coordinators and breath test operators in the chemistry and physiology of breath testing and the pharmacology and metabolism of alcohol.

36. The benzalkonium chloride swab is provided to allay concerns about contaminating the sample with antiseptic alcohol. Isopropanol, the alcohol used by hospitals for that purpose, is readily separated and distinguished from ethanol by the gas chromatographic method of analysis and is not detected by the other methods of analysis used by laboratories in Wisconsin. In any case, it would be very unusual for a specimen collector to collect a sample through skin sufficiently wet with alcohol to contaminate the specimen. Professional laboratory workers know that leaving alcohol on a puncture wound site causes intense pain for the patient or subject.

37. Kier, *Private Forensic Toxicology*, in INTRODUCTION TO FORENSIC TOXICOLOGY 258, 259 (1981).

38. Winek & Paul, *Effect of Short-Term Storage Conditions on Alcohol Concentrations in Blood from Living Human Subjects*, 29 CLINICAL CHEMISTRY 1959, 1959-60 (1983).

hol), isopropanol (rubbing alcohol) and acetone or formaldehyde. The ability to identify these substances is important to SLH toxicologists because they may be present and significant in specimens from coroners.

Most of the approved state laboratories use an enzymatic method of analysis, and one laboratory uses the newly developed radiative energy attenuation (REA) assay. These methods are accurate, precise and specific for ethanol and not subject to interference by any chemicals that could be present in a blood sample. Laboratory approval under section 885.235(10)(a) is contingent upon the applicant using a sound analytical method in the context of a thorough daily and continuing quality assurance program.[39] In addition, all approved laboratories must demonstrate proficiency by achieving satisfactory results in the DHSS monthly proficiency testing program.

Urine is collected without preservatives because the acknowledged effective preservative, mercuric chloride, can cause genital burns in people under the influence attempting to give a sample. SLH toxicologists are also reluctant to provide police officers with a preservative to add to the sample after collection because the addition of anything to the sample could raise doubts about the accuracy of test results.

The SLH does require that the subject completely void and discard any urine in his or her bladder, then provide a second specimen about twenty minutes later. The alcohol in the second specimen will reflect the alcohol content in the blood during the brief collection period. The discarded urine will reflect the alcohol content over an unknown previous period which may not be relevant to the offense and during which the blood alcohol content may have been substantially higher or lower than at the relevant time. Urine collected as specified has an actual alcohol content of 1.1 to 1.5 times the blood alcohol content, with an average of 1.33, the number used to determine the statutory relationship.[40] The statutorily provided calculation is then applied: "[T]he concentration of

39. WIS. STAT. § 885.235(10)(a)(1983-84).
40. Biasotti & Valentine, *supra* note 25, at 203.

alcohol in the blood shall be taken prima facie to be three-fourths of the concentration of alcohol in the urine."[41]

Because of the absence of a preservative, each urine sample which has a measureable alcohol concentration at the SLH is also tested for glucose. Urine samples which are positive for glucose are retested after a week to see whether the alcohol content is changing. The presence of glucose and yeast or certain bacteria can cause fermentation. A small percentage of samples each year have changing alcohol concentrations. Because of this phenomenon the alcohol content of these samples cannot be reported. Despite this disadvantage, jurisdictions which do not have a local hospital with night coverage for collecting blood specimens appreciate the availability of urine as a second test. Both officers and subjects would be inconvenienced by traveling long distances to obtain a blood test.

III. ALCOHOL AND OTHER DRUGS: PHARMACOLOGY AND EFFECTS ON DRIVER PERFORMANCE

A. Effects on Driving Performance

Alcohol is a central nervous system depressant drug.[42] It impairs vision, judgment, coordination and response time.[43] Judgment is impaired even at low alcohol levels.[44] Many people mistakenly believe that alcohol is a stimulant because there is a loss of restraint and inhibitions under its influence. People do things that they would not normally do when sober. A person under the influence of alcohol may be uncharacteristically belligerent, affectionate or verbal. There is an increased willingness to take risks. There is a loss of the ability to judge space and time relationships and an exaggerated belief in one's own competence.[45]

Effects on vision include loss of peripheral vision (tunnel vision), loss of night vision, and at higher concentrations, blurred or double vision. Visual attentiveness decreases, and

41. WIS. STAT. § 885.235(2) (1983-84).

42. *See generally* Ritchie, *The Aliphatic Alcohols*, in THE PHARMACOLOGICAL BASIS OF THERAPEUTICS 143, 143 (3d ed. 1965).

43. *See* AMERICAN MEDICAL ASSOCIATION, ALCOHOL AND THE IMPAIRED DRIVER 27-34 (1972).

44. Ritchie, *supra* note 42 at 144.

45. AMERICAN MEDICAL ASSOCIATION, *supra* note 43, at 33.

the frequency with which drivers shift their gaze from the road to the instrument panel to the rear view mirror is decreased.[46]

Loss of coordination may be evident in staggering gait and poor performance on field sobriety tests. People who are experienced drinkers may not appear intoxicated even at blood alcohol levels well over 0.10% by weight.[47] However, specific tests under controlled conditions comparing scores for tests performed by persons under the influence to the same person's performance while sober will always show impairment at blood alcohol levels of 0.10% by weight.[48]

Alcohol reduces nerve conduction velocity.[49] This results in prolonged response time. This effect is demonstrable and not moderated even in experienced users.[50] Alcohol also reduces the ability to perform complex tasks.

B. Pharmacology of Alcohol

Alcohol is a simple chemical molecule which is readily absorbed, rapidly distributed throughout the body, and metabolized by the liver at a rate which is linear over time.[51] The blood alcohol concentration generally conceded to be lethal is 0.5% by weight. The amount of alcohol in a quart of hard liquor consumed in a few hours is sufficient to produce this blood alcohol concentration in most people. There are rare reports of persons surviving alcohol levels of .6, .7 and even 1.0% by weight. These are remarkable demonstrations of tolerance to this drug.[52]

Normally, about twenty-five percent of ingested alcohol is absorbed from the stomach. The remainder of ingested alco-

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46. Levett, Karras & Hoelft, *Effects of Alcohol on Visual Accomodation and Eye Movement Latency*, in PROCEEDINGS OF THE SIXTH INTERNATIONAL CONFERENCE ON ALCOHOL DRUGS AND TRAFFIC SAFETY, 305, 308 (1975).

47. AMERICAN MEDICAL ASSOCIATION, *supra* note 43, at 9-14.

48. *Id.* at 35-59.

49. *Id.* at 27-34.

50. *Id.*

51. *Id.* at 15-26.

52. Blood alcohol concentrations of 0.5% by weight are generally conceded to be lethal. S. KAYE, *supra* note 7. For other reports of high blood alcohol concentrations see Perper, Twerski & Wienand, *Tolerance at High Blood Alcohol Concentrations: A Study of 110 Cases and Review of the Literature*, 31 J. FORENSIC SCI. 212 (1986).

hol is absorbed from the small intestine.[53] This phenomenon occurs because the intestine has a much larger surface to volume ratio than does the stomach. Alcohol is readily absorbed across any membrane and will be completely absorbed from the stomach even if the entrance to the small intestine is ligated or remains closed due to pyloric valve spasm.[54] It is true that pylorospasm can slow down the absorption of alcohol, as can the presence of food in the stomach. A small quantity of food, however, does not appreciably retard the absorption of a large quantity of alcohol. This fact also is a reflection of the surface to volume relationship.

Alcohol is rapidly distributed throughout the body water.[55] The volume of distribution of alcohol is approximately sixty-eight percent of the male body and fifty-five percent of the female body.[56] Charts relating the number of "drinks" and body weight to a predicted blood alcohol concentration are based on this relationship. The charts are fairly accurate for men, but not for women. If a man and a woman of the same body weight ingest identical amounts of the same alcoholic beverage, the woman's blood alcohol concentration will be higher since she has proportinately less of her body available for its distribution. When using charts, women should subtract approximately twenty percent from the number of drinks that can be consumed before reaching a given blood alcohol concentration or add twenty percent to the estimated blood alcohol obtained after consuming a given number of drinks.[57]

Alcohol is not well distributed in the body fat.[58] Therefore, people who are overweight and wish to use a chart to estimate blood alcohol concentration should use a body weight closer to their ideal body weight than their actual body weight.

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53. AMERICAN MEDICAL ASSOCIATION, *supra* note 43, at 15-26.

54. *See* Cooke & Birchall, *Absorption of Ethanol from the Stomach*, 57 GASTROENTEROLOGY 269 (1969).

55. AMERICAN MEDICAL ASSOCIATION, *supra* note 43, at 15-26.

56. E. WIDMARK, PRINCIPLES AND APPLICATIONS OF MEDICOLEGAL ALCOHOL DETERMINATION 70 (1981).

57. This is derived from the fact that the charts are designed to measure alcohol concentrations in men. Women have 20% less of their body weight available for alcohol distribution than do men. *See id.*

58. AMERICAN MEDICAL ASSOCIATION, *supra* note 43, at 17.

As alcohol is metabolized its effects on the body decrease. Alcohol is metabolized in the liver by the enzyme alcohol dehydrogenase.[59] The end products are carbon dioxide and water. The rate is constant, with an average of 0.015 to 0.018% by weight (blood alcohol concentration) per hour in normal individuals.[60] At blood alcohol levels below 0.020% by weight, the enzyme is not saturated and metabolism may proceed at a slower rate. The normal metabolic rate is equivalent to about a drink an hour for men weighing at least 160 pounds (considering lean body weight, not excess fat) and about one-half of one drink an hour for most women.[61] The rate is somewhat higher in habitual drinkers (0.025 to 0.030% by weight per hour is an average figure for groups of people who habitually drink large amounts of alcohol).[62] Chronic exposure to certain drugs and other foreign substances, such as phenobarbital and some pesticides, may increase the metabolic rate for alcohol. The metabolic rate is decreased in drinkers with liver disease.[63]

Occasionally there are advertisements for over-the-counter preparations purported to sober up a drinker or counter the effects of alcohol. Fructose, a simple sugar, is the only substance which has been shown to have the potential to increase the alcohol metabolism rate slightly after it is consumed.[64] No medication, over-the-counter or prescription, reverses the effects of alcohol. Even fructose does not substantially decrease the number of hours required for a person with a blood alcohol concentration of 0.10% by weight or greater to return to a zero blood alcohol concentration.

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59. *Id.* at 15-26.

60. *Id.*

61. This follows from the fact that the increase in blood alcohol when a man of 160 pounds or greater drinks one ounce of 86 proof alcohol, or one can of beer, is approximately equal to the hourly rate of metabolism of alcohol. The same amount of alcohol will increase the blood alcohol concentration of most women to approximately twice the hourly metabolism rate. Therefore, women should not drink more than one "drink" every two hours if they do not wish to increase their blood alcohol level.

62. Winek & Murphy, *The Rate and Kinetic Order of Ethanol Elimination*, 25 FORENSIC SCI. INT'L 159, 159-66 (1984).

63. AMERICAN MEDICAL ASSOCIATION, *supra* note 43, at 15-26.

64. Meyer, Muller & Hundt, *The Effect of Fructose on Blood Alcohol Levels in Man*, 62 S. AFRICAN MED. J. 719 (1982).

Alcohol is excreted unchanged in the urine, breath and perspiration. Since one effect of alcohol ingestion is reduced anti-diuretic hormone levels resulting in enhanced urine formation,[65] one might expect that a person who produced great quantities of urine while under the influence, or perspired profusely, would have a markedly increased rate of alcohol loss from the body. However, a person with a blood alcohol concentration of 0.15% by weight will excrete only two grams of alcohol per liter of urine or sweat,[66] while the liver metabolizes about seven grams of alcohol each hour.[67] Since a typical drink contains about ten grams of alcohol, it is clear that the alcohol loss due to even extensive sweating or urination is proportionately quite small. The loss in breath is similarly insignificant compared to the calculated metabolic rate.

Blood loss does not substantially affect blood alcohol concentrations unless a sample is collected during or shortly after substantial fluid replacement. One pint of fluid is approximately ten percent of the circulating blood volume.[68] If a sample is taken from the same arm which is receiving fluids, the dilution of the sample can be very substantial and the measured alcohol concentration will be erroneously low. If, however, the sample is taken from the other arm, and if fluid administration is not accelerated due to severe blood loss, the blood alcohol concentration may be a fairly reliable[69] reflection of the concentration prior to the blood loss, since alcohol rapidly re-equilibrates into the new fluid, not only from the remaining blood, but from throughout the body. Thus, if a 150 pound man, who has a body water content available for distribution of about 100 pounds, receives two pints of replacement fluid after losing two pints of blood, his total alcohol loss is only about two percent, a change which will be barely measureable in the blood after equilibration has occurred.

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65. Ritchie, *supra* note 42, at 147.

66. This follows from the urine to blood ratio. *See* Biasotti & Valentine, *supra* note 25.

67. AMERICAN MEDICAL ASSOCIATION, *supra* note 43, at 15-26.

68. Adults have approximately five liters of blood. This measure varies, of course, from person to person depending primarily on body weight.

69. One must, of course, allow for the changes due to metabolism if substantial time has passed.

Pursuant to section 885.235(3) of the Wisconsin Statutes, SLH toxicologists are frequently called upon to give expert testimony to calculate a subject's blood alcohol level at some time prior to the time of a breath test or a blood or urine specimen collection.[70] While some experts maintain that individual variability is so great that it is impossible to calculate a meaningful number except in the most controlled or fortuitous circumstances, we believe it is valid and proper to perform these calculations using the average rate for normal metabolism. Reviewing the information available, the SLH toxicologist will consider whether there may have been unabsorbed alcohol at the time in question and may adjust estimates by subtracting an amount based on the person's gender and weight and the amount and type of alcoholic beverage that may be reasonably assumed to remain unabsorbed in the circumstances given.[71] Thus, one step at a time, SLH toxicologists perform the claculations, stating the assumptions on which those calculations are based. The result is an extrapolated reconstruction of the blood alcohol concentration or range of possible concentrations which does not require knowledge of exactly when the subject's blood alcohol concentration reached its peak.

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70. If the sample of breath, blood or urine was not taken within 3 hours after the event to be proved, evidence of the amount of alcohol in the person's blood or breath as shown by the chemical analysis is admissible only if expert testimony establishes its probative value and may be given prima facie effect only if the effect is established by expert testimony.

WIS. STAT. § 885.235(3) (1983-84).

71. *See infra* notes 58-65 and accompanying text. After many years of doing this, I have yet to meet a defendant who described a condition (e.g., liver disease) that would cause me to believe that a lower metabolic rate would be more appropriate than the average, normal rate. I have seen many defendants for whom I could justifiably have used a higher rate (people who habitually drink to excess), but this would tend to increase my estimate of the blood alcohol concentration at the time of the event to be proved. So, defendants' attorneys are not likely to object to using the normal rate, since it gives the benefit of the doubt to their clients. I have had many cases in which I was asked to calculate the upper and lower limits of my estimate, using maximim and minimum values for all the parameters. This process is tedious but does demonstrate wide variability in some cases. However, in many cases, even the minimum number is well over the statutory limit. In any case, the mean of all the estimates is still what one would obtain if one used the normal, average figures.

C. *Drugs Other Than Alcohol*

Since 1980, SLH has been providing controlled substance and other drug analysis to law enforcement agencies for arrested drivers. A substantial grant from the DOT Office for Highway Safety provided the SLH with state of the art instrumentation as well as the staff and training necessary to implement the best available methods of analysis and confirmation. When an officer or subject requests "controlled substance analysis,"[72] blood is collected and subjected to a battery of immunoassay screening tests for barbituates, amphetamines, opiates, cocaine and phencyclidine. In addition the SLH uses gas and liquid chromatography to identify and quantify many other acidic, basic and neutral drugs. All positives are confirmed by gas chromatography-mass spectrometry, the most specific means of identifying a drug available to toxicologists.

The SLH does not currently test for marijuana because of the lack of a suitable confirmatory test in its laboratory. The Office for Highway Safety has authorized funds for an additional grant for SLH to implement marijuana analysis, and the SHL hopes to have this service available in 1987.

No state has statutory limits for drugs other than alcohol in drivers. Compared to alcohol other drugs are not metabolized in a linear fashion.[73] Nor are they distributed uniformly; blood drug concentrations may return to unremarkable levels while tissue drug levels and impairment are still high.[74] The effects of alcohol have been so thoroughly studied under so many different conditions that toxicologists know all drivers are measureably impaired at 0.10% by weight of blood alcohol, even if they are experienced drinkers and skilled drivers. Extensive studies are not available for other drugs with the exception of diazepam and diazepam/alcohol combinations.[75] Especially lacking are studies of drivers habituated or tolerant to drugs other than alcohol. Presumptive limits set sufficiently high to permit people habituated to medication to drive legally would also permit occasional recreational drug

72. *See* 1983 Wis. Laws 459, § 12 (to be codified at WIS. STAT. § 346.63(1)(a)).

73. *Drug Concentrations and Driving Impairment*, 254 J.A.M.A. 2618, 2618-21 (1985).

74. *Id.*

75. *Id.*

users and people with new prescriptions to drive. Unfortunately, inexperienced users are likely to be dangerously impaired at such high blood drug levels.

Interpreting levels of other drugs in drivers requires some knowledge and reflection. The arresting officer must make careful observations of the driving and field sobriety tests to clearly demonstrate impairment. It is helpful to know whether the subject had a prescription for the drug and whether the subject was a long term, habitual user. Finally, the concentrations of drugs found must be compared to the therapeutic ranges and to whatever is known about the effects of the drug on the skills necessary for safe driving.

CONCLUSION

Wisconsin statutes and administrative regulations provide a scientifically sound and well coordinated system for assuring both drinking drivers and traffic safety enforcement personnel fair and accurate detection tests for alcohol and other drugs. This facilitates fair and accurate enforcement of, and penalty for, alcohol and other drug use violations.