Table of Contents

Abbreviations and Definitions

Version: Controlled document revision number after SharePoint controlled document migration (October, 2021)

Absorptive: The period of time during which alcohol has not yet been completely absorbed into the blood stream

ADH: Alcohol dehydrogenase, the enzyme primarily responsible for ethanol metabolism

C_0: The maximum alcohol content achievable for a specific alcohol dose and total body water content

dL: Deciliter, a unit of volume equal to 100 mL

EDTA: Ethylenediaminetetraacetic acid, a chemical sometimes used as an anticoagulant for blood

g: Gram, a unit of mass

Gastric emptying: The rate at which food and/or beverages in the stomach move into the small intestine

L: Liter, a unit of volume

mg: Milligram, a unit of mass

mL: Milliliter, a unit of volume

oz: Ounce, a non-SI unit of volume, equal to 29.6 mL

Plasma: The liquid remaining after whole blood is treated with an anticoagulant and the blood cells are removed

Post-absorptive: The period of time after which ingested alcohol has been completely absorbed into the blood stream

Proof: Two times the alcohol percent by volume (ABV or %v/v), an expression of concentration

Rho factor: Body water (liters) per kilogram of body weight

Serum: The liquid remaining when blood is collected without an anticoagulant and allowed to clot

SI: International System of Units, also known as the metric system

Venous blood: Blood from a vein

%v/v: The volume of ethanol per volume of the total solution, expressed as a percentage; a unit of concentration. Also known as "ABV" (alcohol by volume).

Introduction

The intent of this manual is to describe how forensic scientists within the forensic alcohol discipline at the Scientific Crime Detection Laboratory will interpret the results of blood and breath alcohol measurements. It also serves as a summary to the legal community as to what to expect when a forensic scientist's testimony is to include alcohol interpretation.

Ethanol

The chemical name for the alcohol that is commonly consumed is ethanol (or ethyl alcohol). In this document, alcohol and ethanol are used interchangeably. Ethanol is a small, water-soluble molecule that is readily absorbed and distributed by the blood throughout all the water-containing components of the body.

Alcohol Proof

The concentration of an alcoholic beverage is commonly listed in the units of proof. The concentration of alcohol in percent by volume is one half the proof.

80 Proof = 40 % (v/v)

The common abbreviations for alcohol percent by volume are ABV and % (v/v). The volume of pure ethanol can be converted to its mass using ethanol's density.

1 mL ethanol = 0.789 grams ethanol

Standard Drinks

The term "standard drink" applies to drinks of "standard" alcoholic strength. **In the United States, a standard drink is defined as containing 14 grams of ethanol.**[1] The resulting concentration of ethanol (% v/v) when 14 grams of pure ethanol is diluted to a given volume can be calculated as follows:

$$Concentration\ in\ ABV\ or\ \%v/v = \frac{(100 \times 14\ grams)}{(Volume\ of\ drink\ (oz) \times 29.6\frac{mL}{oz} \times 0.789\frac{grams\ ethanol}{mL})}$$

This gives the following drink concentrations for a United States standard alcoholic drink containing 14 grams of alcohol:

12 ounces of 5% (v/v) beer

5 ounces of 12% (v/v) wine

1.5 ounces of 40% (v/v) spirits

Common Unit Conversions

The Crime Laboratory reports blood alcohol concentrations in units of “grams per 100 milliliters” abbreviated as g/100mL. Other laboratories may use the units of “grams per deciliter” abbreviated g/dL. Because one deciliter equals 100 milliliters, these units are equivalent.

0.080 g/100mL = 0.080 g/dL

Alcohol concentrations reported in medical results are commonly in units of “milligrams per deciliter”, abbreviated mg/dL. Because one gram equals 1000 milligrams, mg/dL can be converted to g/dL by dividing by 1000.

80 mg/dL = 0.080 g/dL = 0.080 g/100mL

Converting Serum and Plasma Results to Whole Blood Concentration

Although hospital results frequently report alcohol concentrations as being from blood, serum or plasma is often the sample analyzed. Ethanol distributes throughout all water-containing components of the body in proportion to their water content**. Since serum or plasma represents the water portion of whole blood, alcohol results from serum or plasma will have a higher alcohol content than the whole blood from which the serum or plasma originated.**

The average ratio of serum and plasma alcohol content to whole blood alcohol content is approximately 1.14:1 with a range of 1.04:1 to 1.26:1.[2] The whole blood concentration may be calculated from the serum or plasma alcohol concentration result by using the average ratio.

Whole blood alcohol content = Serum or Plasma Alcohol Content / 1.14

Breath and Blood Alcohol

Breath alcohol instruments indirectly estimate blood alcohol concentration using a calibration factor called the blood/breath ratio. This ratio describes how the concentration of alcohol in a person’s venous blood relates to the concentration of alcohol in their deep lung air.

Breath instruments in the United States assume a blood/breath ratio of 2100:1. Studies have shown that the blood/breath ratio is less than 2000:1 during the absorptive phase, increasing to about 2100:1 by 90 minutes post -dosing, and further increasing to 2300:1 or 2400:1 later in the post-absorptive phase.[3] Because of the variability in an individual’s blood/breath ratio, a breath alcohol concentration result should not be converted to a blood alcohol concentration. Despite this variability in the blood/breath ratio, both breath and blood alcohol testing are valid when determining someone’s current alcohol content.

The Alaska Administrative Code lists the legal limit of 0.08 in both blood (g/100mL) and breath (g/210L) units making any conversion between the two unnecessary.[4]

Ethanol Physiology and Pharmacology

Ethanol In the Human Body

General Alcohol Concentration Curve

When a person consumes alcohol, the time course of ethanol concentration in the blood can be divided into three phases: absorptive, peak, and post-absorptive. These phases are illustrated in Figure 1.[2]

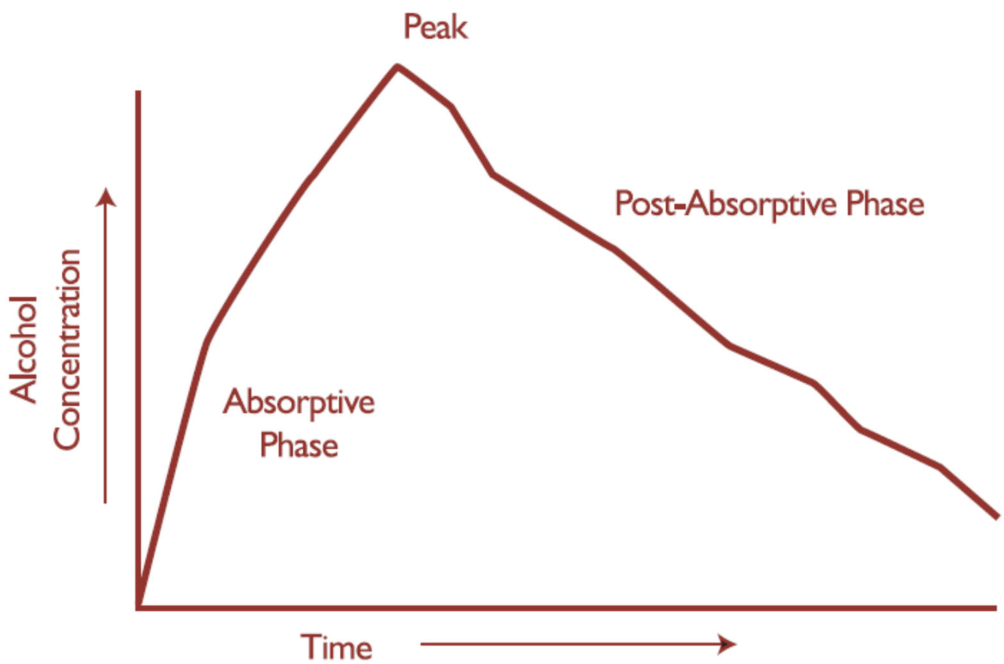

Figure 1: General alcohol concentration curve

As soon as alcohol is absorbed into the body, the body begins to eliminate it. During the absorptive phase, alcohol concentration is increasing at a faster rate than it is being eliminated, at the peak, absorption and elimination rates are equal, and after absorption of alcohol is complete, the alcohol concentration will decrease until it reaches zero.

Absorption

When alcohol is ingested, about 20-25% of the dose is absorbed through the stomach lining and the remaining 75-80% is absorbed when it leaves the stomach and enters the small intestine.[2] The most important factor affecting the rate of absorption is whether food is present in the stomach at the same time as alcohol. **Peak concentrations are generally attained within 30 to 60 minutes of the cessation of drinking.[2]** When alcohol is consumed successively over time, as in a social drinking situation, peak concentrations are generally attained within 30 minutes of the last drink and may even be attained before the last drink is finished.[2]

Distribution

Because alcohol is completely water soluble, the alcohol concentration in the body after absorbing a given dose is proportional to a person's total water content. **The more water a person has in their body, the less concentrated a given dose of alcohol will be after it is absorbed and distributed.** About 68% of an average male's body weight is due to body water (0.68 L/kg), while the percentage is 55% for average females (0.55 L/kg).[2]

Metabolism and Elimination

At blood alcohol concentrations above 0.02 g/100mL, the metabolic capacity of the primary enzyme responsible for ethanol elimination (hepatic alcohol dehydrogenase) is saturated.[3] This means that the rate of ethanol elimination is independent of the remaining ethanol concentration in the blood (zero-order kinetics).

The majority of the human population eliminates alcohol at a rate between 0.010 g/100mL/hr and 0.025 g/100mL/hr with an average elimination rate of 0.017 g/100mL/hr.[3]

Factors that may have an effect on an individual's elimination rate include how well-nourished the person is and whether continuous drinking has occurred over a period of several days.[3] An individual's elimination rate will vary and, rather than speculating over what their specific elimination rate was during the time of interest, it is more practical to use the elimination range and average listed above.[3]

Impairing Effects of Ethanol

Ethanol is a central nervous system depressant. The magnitude of its depressant effects is dependent on the dose consumed. The depressant effects of alcohol cause an increase in reaction time (slowed information processing), a decrease in judgment, and a decrease in coordination.

Outward signs of intoxication may vary based on the individual. Figure 2 outlines some clinical signs and symptoms of ethanol intoxication and the blood alcohol ranges at which they may be observed.[5]

STAGES OF ACUTE ALCOHOLIC INFLUENCE/INTOXICATION

BLOOD-ALCOHOL CONCENTRATION grams/100 mL	STAGE OF ALCOHOLIC INFLUENCE	CLINICAL SIGNS/SYMPTOMS
0.01-0.05	**Subclinical**	Influence/effects usually not apparent or obvious Behavior nearly normal by ordinary observation Impairment detectable by special tests
0.03-0.12	**Euphoria**	Mild euphoria, sociability, talkativeness Increased self-confidence; decreased inhibitions Diminished attention, judgment and control Some sensory-motor impairment Slowed information processing Loss of efficiency in critical performance tests
0.09-0.25	**Excitement**	Emotional instability; loss of critical judgment Impairment of perception, memory and comprehension Decreased sensitory response; increased reaction time Reduced visual acuity & peripheral vision; and slow glare recovery Sensory-motor incoordination; impaired balance; slurred speech; vomiting; drowsiness
0.18-0.30	**Confusion**	Disorientation, mental confusion; vertigo; dysphoria Exaggerated emotional states (fear, rage, grief, etc) Disturbances of vision (diplopia, etc.) and of perception of color, form, motion, dimensions Increased pain threshold Increased muscular incoordination; staggering gait; ataxia Apathy, lethargy
0.25-0.40	**Stupor**	General inertia; approaching loss of motor functions Markedly decreased response to stimuli Marked muscular incoordination; inability to stand or walk Vomiting; incontinence of urine and feces Impaired consciousness; sleep or stupor
0.35-0.50	**Coma**	Complete unconsciousness; coma; anesthesia Depressed or abolished reflexes Subnormal temperature Impairment of circulation and respiration Possible death
0.45+	**Death**	Death from respiratory arrest

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Figure 2: Ethanol Impairment Signs and Symptoms Chart.

Relative Crash Risk

Studies have compared the relative vehicle crash risk of people at a specific alcohol level to people with no alcohol in their system.[6, 7] Relative crash risk asks the question, "What are the odds of a person getting in an accident at a particular BAC compared to the odds of a person getting in an accident with no alcohol in their system?" Mathematically, this is expressed as:

$$Relative\ Crash\ Risk = \frac{\left(\frac{N_{crash}}{N_{control}}\right)_{BAC=x}}{\left(\frac{N_{crash}}{N_{control}}\right)_{BAC=0}}$$

The largest of these studies used crash data from Grand Rapids, Michigan (MI) and more recently in Long Beach, California (CA) and Fort Lauderdale, Florida (FL).

As illustrated in Figure 3, results confirm a notable dose-response relationship beginning at 0.04 g/100mL and increasing exponentially at greater than 0.10 g/100mL.[6]

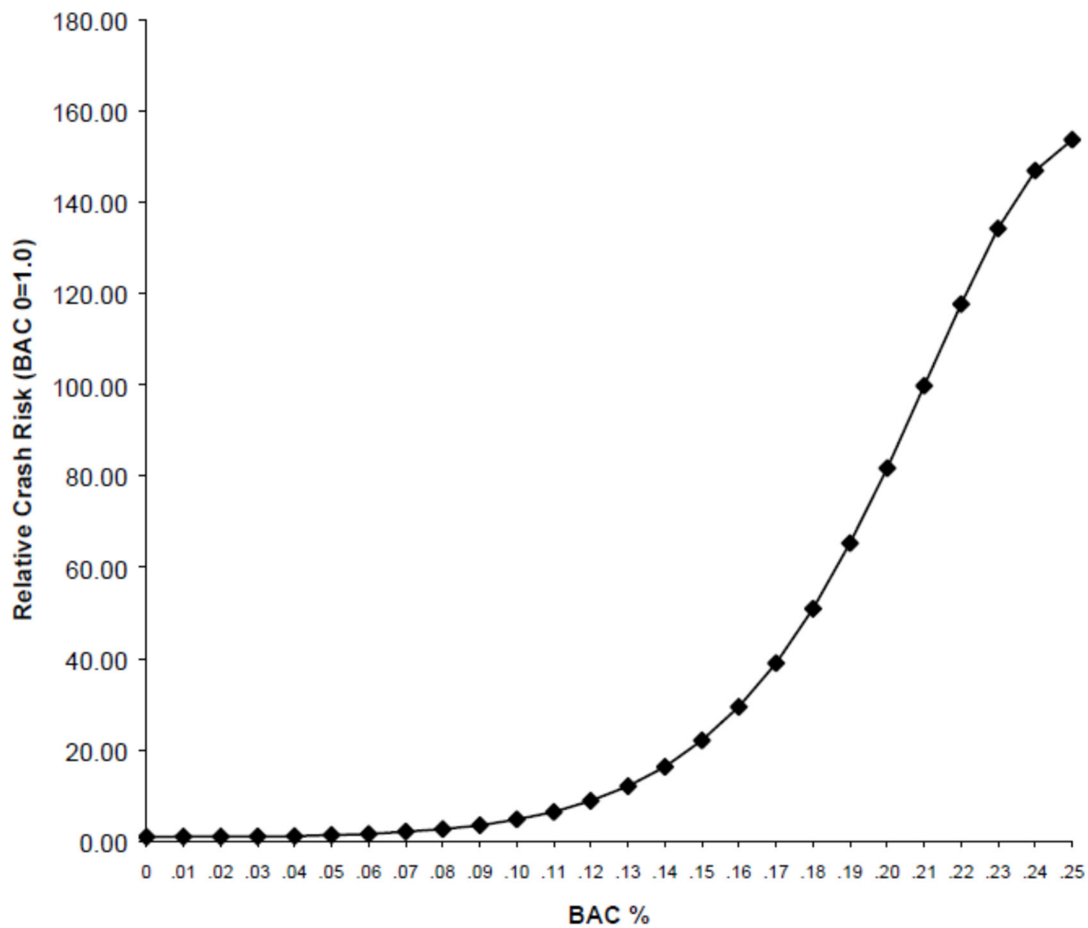

Figure 3: Relative crash risk at varying BAC %.

Figure 3 shows these results in tabulated form[7].

Table ES-1. Relative Risk Models

	Relative Risk			
BAC	No Covariates	Non-reactive Demographic Covariates	Final Adjusted Estimate	Grand Rapids*
0.00	1.00	1.00	1.00	1.00
.01	.91	.94	1.03	.92
.02	.87	.92	1.03	.96
.03	.87	.94	1.06	.80
.04	.92	1.00	1.18	1.08
.05	1.00	1.10	1.38	1.21
.06	1.13	1.25	1.63	1.41
.07	1.32	1.46	2.09	1.52
.08	1.57	1.74	2.69	1.88
.09	1.92	2.12	3.54	1.95
.10	2.37	2.62	4.79	5.93
.11	2.98	3.28	6.41	
.12	3.77	4.14	8.90	4.94
.13	4.78	5.23	12.06	
.14	6.05	6.60	16.36	10.44
.15	7.61	8.31	22.10	
.16	9.48	10.35	29.48	21.38
.17	11.64	12.74	39.05	
.18	14.00	15.43	50.99	
.19	16.45	18.31	65.32	
.20	18.78	21.20	81.79	
.21	20.74	23.85	99.78	
.22	22.07	25.99	117.72	
.23	22.51	27.30	134.26	
.24	21.92	27.55	146.90	
.25+	20.29	26.60	153.68	

*From reporting of Grand Rapids Study data in Table 25 (a) of Allsop (1966).

Figure 4: Relative crash risk study results in table format.

The authors of the Grand Rapids study concluded that at or above a 0.08% blood alcohol level, factors other than alcohol became less and less significant and eventually seemed to disappear.[6] This is compelling evidence that alcohol is a major factor in traffic crash causation. In addition to these studies, the Committee on Alcohol and Other Drugs of the National Safety Council have concluded that all individuals are impaired with respect to operating a motor vehicle at concentrations of 0.08 and above, while some individuals are impaired with respect to driving at concentrations below 0.08.[2]

Forensic Alcohol Calculations

Disclaimer: The calculations described in this section should be viewed as a general guideline or rough estimate. While based on accepted scientific principles and peer-reviewed data, a calculated alcohol concentration is not as accurate or reliable as a measured breath or blood alcohol concentration.

The Widmark Formula

The Widmark Formula is used to answer these questions:

What is the minimum number of drinks needed to reach a certain level?

What would their maximum possible alcohol content be given a certain dose of alcohol?

The Widmark formula can be used to calculate a person's **maximum alcohol content** for a given gender, body weight, and dose of alcohol. It assumes instantaneous and complete absorption of the entire alcohol dose into a person's systemic blood. Conversely, the formula can be used to calculate the **minimum amount of alcohol that must be consumed** to achieve a given alcohol content.

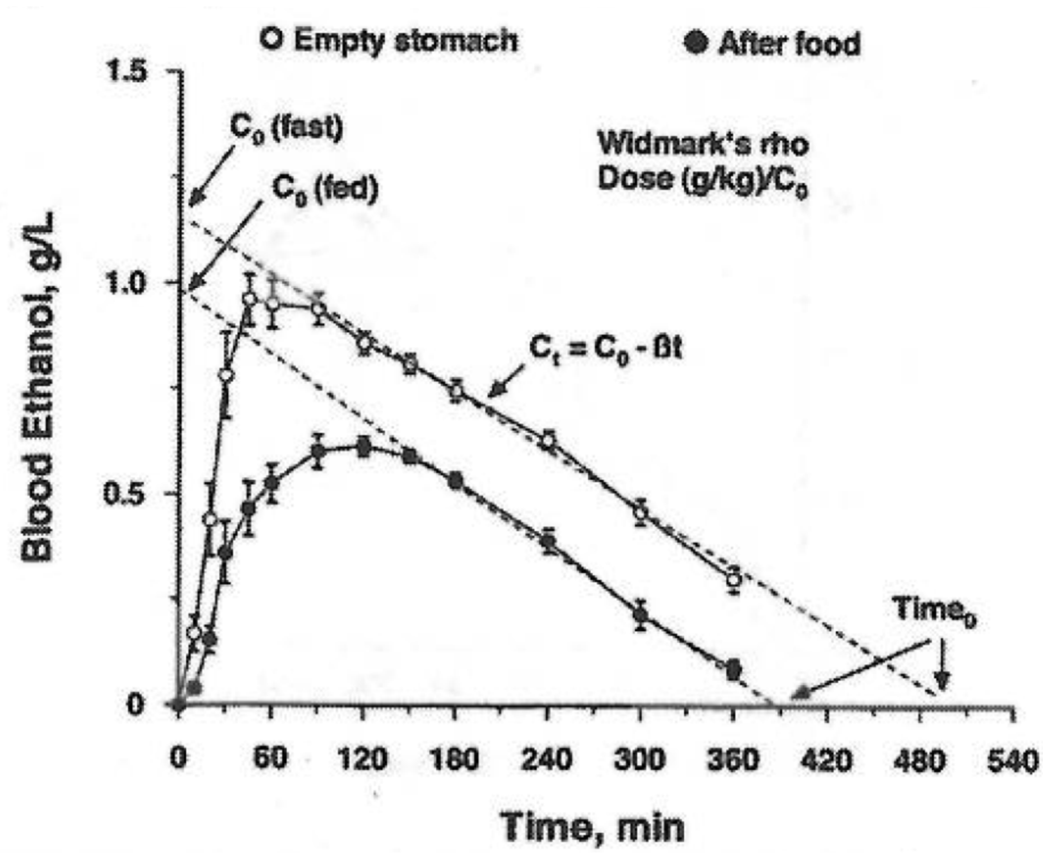

Figure 5: Widmark concept and the effect of food on bioavailability

Figure 5 illustrates the concept behind the Widmark formula.[8] When a line is extrapolated from the linear post-absorptive phase of an individual's alcohol concentration curve (solid line) back to time zero, the y-intercept represents that individual's alcohol content if the entire alcohol dose was instantaneously absorbed into the blood. This concentration is denoted C_0. A factor called "rho" by Widmark is the dose of alcohol consumed divided by C_0. The rho factor represents the percent of a person's body weight due to body water and is also referred to as the volume of distribution (V_D) of ethanol.

Widmark calculations performed by the lab assume a rho factor of 0.68 L/kg for males and 0.55 L/kg for females. This factor can range from about 0.4 L/kg for an obese female to 0.85 L/kg for a muscular male.[3]

Body weight in grams may be calculated from body weight in pounds with the formula:

$$Body\ weight\ (grams) = Body\ weight\ in\ pounds \times 454 \frac{grams}{pound}$$

When calculating maximum alcohol content, the Widmark formula is:

$$Maximum\ alcohol\ content\ \left(\frac{g}{100\ mL}\right) = \frac{100 \times Alcohol\ dose\ (grams)}{Body\ weight\ (grams) \times rho\ factor}$$

This formula can be rearranged to calculate the minimum dose of alcohol required to achieve a given alcohol content as follows:

$$Minimum\ alcohol\ dose\ (grams) = \frac{Alcohol\ content\ \left(\frac{g}{100\ mL}\right) \times Body\ weight\ (grams) \times rho\ factor}{100}$$

The alcohol dose in grams and body weight in grams can be determined using the following formulas:

$$Alcohol\ dose\ (grams) = volume\ of\ drink\ (ounces) \times 29.6 \frac{mL}{ounce} \times \left(\frac{ABV}{100}\right) \times 0.789 \frac{grams\ ethanol}{mL}$$

See Appendix 1: Widmark Tables for Males and Females for tables that give Widmark calculation values based on gender, weight, and number of standard drinks consumed.

When rho factors were determined by Widmark, the experiment consisted of people rapidly drinking the entire dose of alcohol within 5 to 15 minutes on an empty stomach.[3] These conditions maximize the percent of the dose that makes it from the stomach into systemic blood. This percentage is called "bioavailability".

When drinking with or after a meal, or in repetitive alcohol doses over several hours, the bioavailability of ethanol may be considerably less than 100%.[3, 8, 9] **This decrease in alcohol bioavailability is sometimes called an "alcohol deficit" and should be taken into consideration when discussing long social drinking situations or consumption of food with alcohol.[9]** The alcohol deficit is illustrated in Figure 5 by a lowering of C_0 (fast vs fed) when a person is given the same dose of alcohol on a fed stomach versus an empty one. A likely explanation for this decrease is the presence of food in the stomach delaying gastric emptying. The increased time in the stomach results in an increased contact time with gastric alcohol dehydrogenase (ADH) in the stomach before the alcohol reaches systemic blood.[3, 8, 9]

Figure 6 illustrates an alcohol concentration curve when ethanol is administered intravenously.[10]

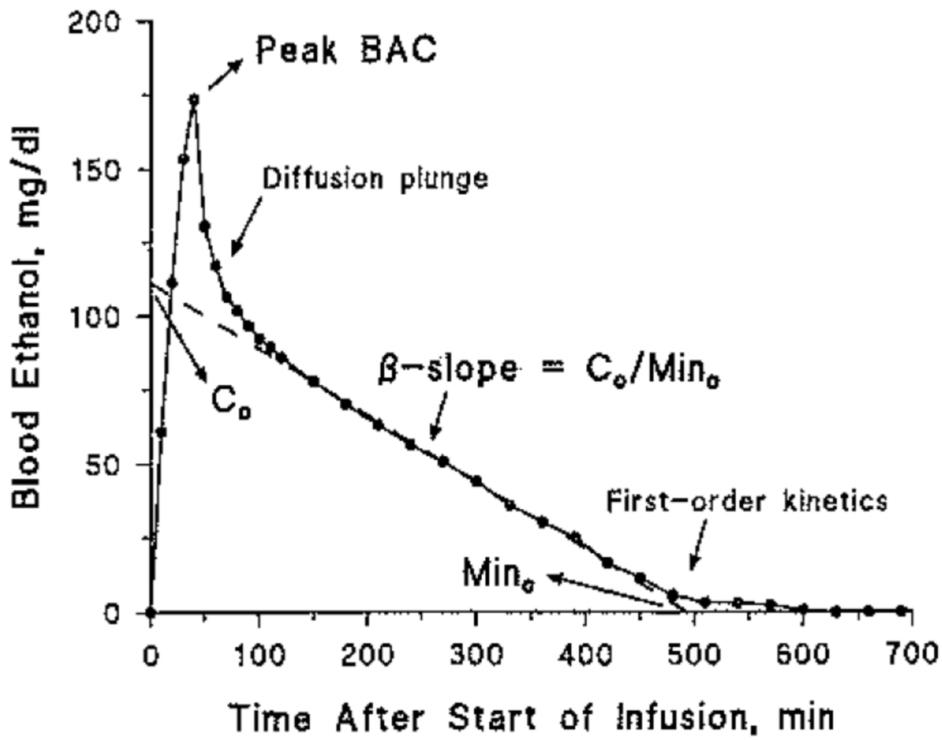

Figure 6: Diffusion plunge after intravenous infusion of ethanol

When alcohol very rapidly enters the blood stream (e.g., intravenous infusion), the initial true blood alcohol concentration can be higher than the concentration predicted by the Widmark equation. This is due to the alcohol initially not having time to equilibrate between the central (blood) compartment into the peripheral tissues, where most of the body water is present. The rapid drop that occurs from peak concentration to equilibrated concentration is known as the “diffusion plunge”. While this situation generally does not occur when alcohol is consumed orally, it may occur with people who have undergone gastric bypass surgery.[11]

Extrapolation

Forward Extrapolations

"What could their alcohol content have been N hours after the start of drinking?"

Starting with the maximum alcohol concentration calculated with the Widmark formula (C_0), an estimate of a person's maximum alcohol content at a time after drinking began can be made using the range of elimination rates listed previously (Metabolism and Elimination). In Figures 5 and 6, this is essentially tracing from where the extrapolated line intercepts the y-axis forward to a specific time and determining what the corresponding alcohol content is:

$$Maximum\ alcohol\ content\ N\ hours\ later = Maximum\ alcohol\ content - (Elimination\ rate \times N\ hours)$$

Retrograde (Backward) Extrapolations

"Given an alcohol result, what could their results have been N hours earlier?"

Like an estimate of an individual's alcohol content hours after drinking began starting with the maximum alcohol content calculated using the Widmark formula, an estimate can be made of an individual's alcohol content hours before their alcohol content was measured starting with the result of that measurement.

$$Maximum\ alcohol\ content\ N\ hours\ earlier = Measured\ alcohol\ content + (Elimination\ rate \times N\ hours)$$

Accounting for Unabsorbed Alcohol

"What if they drank immediately before the incident?"

Note that the extrapolated dotted line in Figure 5 does not meet with the alcohol concentration curve (solid line) until the post-absorptive phase is reached**. When performing extrapolations, the laboratory will assume that the post-absorptive phase has been reached within one hour after the last drink is consumed.** If the time between when the last drink was consumed and when the measured result is being extrapolated back to is less than one hour, the effect of unabsorbed alcohol will be considered:

$$Maximum\ alcohol\ content\ N\ hours\ earlier = Measured\ alcohol\ content + (Elimination\ rate \times N\ hours) - Unabsorbed\ alcohol$$

The contribution to an individual's measured alcohol content due to unabsorbed alcohol at the time of the incident will be calculated using the Widmark formula (see Appendix 1: Widmark Tables for Males and Females).[2] If no information is provided regarding the dose of alcohol consumed within the hour before the time extrapolated to, a standard dose of 14 grams of ethanol will be assumed.

Accounting for Post-incident Alcohol Consumption

"What if they drank after the incident but before the test?"

If alcohol consumption is suspected between the time extrapolated back to and the time of the test, the same technique used to account for unabsorbed alcohol will be used to account for post-incident consumption where the maximum alcohol content N hours earlier equals:[2]

$$Maximum\ alcohol\ content\ N\ hours\ earlier = Measured\ alcohol\ content + (Elimination\ rate \times N\ hours) - Post\ incident\ consumption$$

As with estimating the effect of unabsorbed alcohol, if no information is provided regarding the dose of alcohol consumed post-incident, a standard dose of 14 grams will be assumed.

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Forensic Alcohol Core Module Readings - Laboratory SharePoint Document Library

Appendix 1: Widmark Tables for Males and Females

Alcohol Chart for Males[1]

Number of Standard Drinks[2]

Body Weight	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
100	0.045	0.091	0.136	0.181	0.227	0.272	0.317	0.363	0.408	0.453	0.499	0.544	0.590	0.635	0.680
110	0.041	0.082	0.124	0.165	0.206	0.247	0.289	0.330	0.371	0.412	0.453	0.495	0.536	0.577	0.618
120	0.038	0.076	0.113	0.151	0.189	0.227	0.265	0.302	0.340	0.378	0.416	0.453	0.491	0.529	0.567
130	0.035	0.070	0.105	0.140	0.174	0.209	0.244	0.279	0.314	0.349	0.384	0.419	0.453	0.488	0.523
140	0.032	0.065	0.097	0.130	0.162	0.194	0.227	0.259	0.292	0.324	0.356	0.389	0.421	0.453	0.486
150	0.030	0.060	0.091	0.121	0.151	0.181	0.212	0.242	0.272	0.302	0.333	0.363	0.393	0.423	0.453
160	0.028	0.057	0.085	0.113	0.142	0.170	0.198	0.227	0.255	0.283	0.312	0.340	0.368	0.397	0.425
170	0.027	0.053	0.080	0.107	0.133	0.160	0.187	0.213	0.240	0.267	0.293	0.320	0.347	0.373	0.400
180	0.025	0.050	0.076	0.101	0.126	0.151	0.176	0.202	0.227	0.252	0.277	0.302	0.328	0.353	0.378
190	0.024	0.048	0.072	0.095	0.119	0.143	0.167	0.191	0.215	0.239	0.263	0.286	0.310	0.334	0.358
200	0.023	0.045	0.068	0.091	0.113	0.136	0.159	0.181	0.204	0.227	0.249	0.272	0.295	0.317	0.340
210	0.022	0.043	0.065	0.086	0.108	0.130	0.151	0.173	0.194	0.216	0.238	0.259	0.281	0.302	0.324
220	0.021	0.041	0.062	0.082	0.103	0.124	0.144	0.165	0.186	0.206	0.227	0.247	0.268	0.289	0.309
230	0.020	0.039	0.059	0.079	0.099	0.118	0.138	0.158	0.177	0.197	0.217	0.237	0.256	0.276	0.296
240	0.019	0.038	0.057	0.076	0.094	0.113	0.132	0.151	0.170	0.189	0.208	0.227	0.246	0.265	0.283
250	0.018	0.036	0.054	0.073	0.091	0.109	0.127	0.145	0.163	0.181	0.200	0.218	0.236	0.254	0.272
260	0.017	0.035	0.052	0.070	0.087	0.105	0.122	0.140	0.157	0.174	0.192	0.209	0.227	0.244	0.262
270	0.017	0.034	0.050	0.067	0.084	0.101	0.118	0.134	0.151	0.168	0.185	0.202	0.218	0.235	0.252
280	0.016	0.032	0.049	0.065	0.081	0.097	0.113	0.130	0.146	0.162	0.178	0.194	0.211	0.227	0.243
290	0.016	0.031	0.047	0.063	0.078	0.094	0.109	0.125	0.141	0.156	0.172	0.188	0.203	0.219	0.235
300	0.015	0.030	0.045	0.060	0.076	0.091	0.106	0.121	0.136	0.151	0.166	0.181	0.197	0.212	0.227

This table uses the Widmark formula to calculate a person's **maximum alcohol content** for a given gender, body weight, and dose of alcohol.
It assumes instantaneous and complete absorption of the entire alcohol dose into a person's systemic blood.
Conversely, the table can be used to calculate the **minimum amount of alcohol that must be consumed** to achieve a given alcohol content.

[1] All calculations in this table assume a **Widmark rho factor of 0.68 L/kg for males and 0.55 L/kg for females.** The rho factor represents the percent of a person's body weight due to body water. It can range from about 0.4 L/kg for an obese female to 0.85 L/kg for a muscular male.

[2] A U.S. standard drink contains **14 g of pure ethanol**. This is equivalent to:

- 12 ounces of 5% (v/v) beer
- 5 ounces of 12% (v/v) wine
- 1.5 ounces of 40% (v/v) liquor

For non standard drinks and/or rho factors, maximum alcohol content can be calculated using the Widmark formula as follows:

Maximum alcohol content (g/dL) = 100***Alcohol dose in grams**/(**body weight in grams*****Widmark rho factor**)

where

Alcohol dose in grams = (Volume of drinks in ounces)*(29.6 mL/oz)*(Concentration of alcohol in drink/100)*(0.789 g/mL)

and

body weight in grams = (body weight in pounds)*(454 g/lb)

Alcohol Chart for Females[1]

Number of Standard Drinks[2]

Body Weight	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
100	0.056	0.112	0.168	0.224	0.280	0.336	0.392	0.449	0.505	0.561	0.617	0.673	0.729	0.785	0.841
110	0.051	0.102	0.153	0.204	0.255	0.306	0.357	0.408	0.459	0.510	0.561	0.612	0.663	0.714	0.765
120	0.047	0.093	0.140	0.187	0.234	0.280	0.327	0.374	0.421	0.467	0.514	0.561	0.607	0.654	0.701
130	0.043	0.086	0.129	0.173	0.216	0.259	0.302	0.345	0.388	0.431	0.474	0.518	0.561	0.604	0.647
140	0.040	0.080	0.120	0.160	0.200	0.240	0.280	0.320	0.360	0.400	0.441	0.481	0.521	0.561	0.601
150	0.037	0.075	0.112	0.150	0.187	0.224	0.262	0.299	0.336	0.374	0.411	0.449	0.486	0.523	0.561
160	0.035	0.070	0.105	0.140	0.175	0.210	0.245	0.280	0.315	0.350	0.385	0.421	0.456	0.491	0.526
170	0.033	0.066	0.099	0.132	0.165	0.198	0.231	0.264	0.297	0.330	0.363	0.396	0.429	0.462	0.495
180	0.031	0.062	0.093	0.125	0.156	0.187	0.218	0.249	0.280	0.311	0.343	0.374	0.405	0.436	0.467
190	0.030	0.059	0.089	0.118	0.148	0.177	0.207	0.236	0.266	0.295	0.325	0.354	0.384	0.413	0.443
200	0.028	0.056	0.084	0.112	0.140	0.168	0.196	0.224	0.252	0.280	0.308	0.336	0.364	0.392	0.421
210	0.027	0.053	0.080	0.107	0.133	0.160	0.187	0.214	0.240	0.267	0.294	0.320	0.347	0.374	0.400
220	0.025	0.051	0.076	0.102	0.127	0.153	0.178	0.204	0.229	0.255	0.280	0.306	0.331	0.357	0.382
230	0.024	0.049	0.073	0.098	0.122	0.146	0.171	0.195	0.219	0.244	0.268	0.293	0.317	0.341	0.366
240	0.023	0.047	0.070	0.093	0.117	0.140	0.164	0.187	0.210	0.234	0.257	0.280	0.304	0.327	0.350
250	0.022	0.045	0.067	0.090	0.112	0.135	0.157	0.179	0.202	0.224	0.247	0.269	0.292	0.314	0.336
260	0.022	0.043	0.065	0.086	0.108	0.129	0.151	0.173	0.194	0.216	0.237	0.259	0.280	0.302	0.323
270	0.021	0.042	0.062	0.083	0.104	0.125	0.145	0.166	0.187	0.208	0.228	0.249	0.270	0.291	0.311
280	0.020	0.040	0.060	0.080	0.100	0.120	0.140	0.160	0.180	0.200	0.220	0.240	0.260	0.280	0.300
290	0.019	0.039	0.058	0.077	0.097	0.116	0.135	0.155	0.174	0.193	0.213	0.232	0.251	0.271	0.290
300	0.019	0.037	0.056	0.075	0.093	0.112	0.131	0.150	0.168	0.187	0.206	0.224	0.243	0.262	0.280

This table uses the Widmark formula to calculate a person's **maximum alcohol content** for a given gender, body weight, and dose of alcohol.
It assumes instantaneous and complete absorption of the entire alcohol dose into a person's systemic blood.
Conversely, the table can be used to calculate the **minimum amount of alcohol that must be consumed** to achieve a given alcohol content.

[1]All calculations in this table assume a **Widmark rho factor of 0.68 L/kg for males and 0.55 L/kg for females.** The rho factor represents the percent of a person's body weight due to body water. It can range from about 0.4 L/kg for an obese female to 0.85 L/kg for a muscular male.

[2]A U.S. standard drink contains **14 g of pure ethanol**. This is equivalent to:

- 12 ounces of 5% (v/v) beer
- 5 ounces of 12% (v/v) wine
- 1.5 ounces of 40% (v/v) liquor

For non standard drinks and/or rho factors, maximum alcohol content can be calculated using the Widmark formula as follows:
Maximum alcohol content (g/dL) = 100***Alcohol dose in grams**/(**body weight in grams*****Widmark rho factor**)
where
Alcohol dose in grams = (Volume of drinks in ounces)*(29.6 mL/oz)*(Concentration of alcohol in drink/100)*(0.789 g/mL)
and
body weight in grams = (body weight in pounds)*(454 g/lb)

Appendix 2: Blood Tube Top Colors and their Additives

 **Gold**	 **Red/ Gray**	• Clot activator and gel for serum separation
 **Light Green**	 **Green/ Gray**	• Lithium heparin and gel for plasma separation
 **Red**	 **Red**	• Silicone coated (glass) • Clot activator, Silicone coated (plastic)
 **Orange**		• Thrombin-based clot activator with gel for serum separation
 **Orange**		• Thrombin-based clot activator
 **Royal Blue**		• Clot activator (plastic serum) • K_2EDTA (plastic)
 **Green**	 **Green**	• Sodium heparin • Lithium heparin
 **Gray**	 **Gray**	• Potassium oxalate/ sodium fluoride • Sodium fluoride/Na_2 EDTA • Sodium fluoride (serum tube)
 **Tan**		• K_2EDTA (plastic)

	 **Yellow**	• Sodium polyanethol sulfonate (SPS) • Acid citrate dextrose additives (ACD): **Solution A -** 22.0 g/L trisodium citrate, 8.0 g/L citric acid, 24.5 g/L dextrose **Solution B -** 13.2 g/L trisodium citrate, 4.8 g/L citric acid, 14.7 g/L dextrose
 **Lavender**	 **Lavender**	• Liquid K_3EDTA (glass) • Spray-coated K_2EDTA (plastic)
 **White**		• K_2EDTA and gel for plasma separation
 **Pink**	 **Pink**	• Spray-coated K_2 EDTA (plastic)
 **Light Blue**  **Clear**	 **Light Blue**	• Buffered sodium citrate 0.105 M (≈3.2%) glass 0.109 M (3.2%) plastic • Citrate, theophylline, adenosine, dipyridamole (CTAD)
 **Clear**	 **New** **Red/ Light Gray**	• None (plastic)

Source: BD Diagnostics, BD Vacutainer Venous Blood Collection Tube Guide, 2010

Revision History

Location	Revision made
The Widmark Formula	Corrected the Alcohol dose in grams equation to incorporate conversion from ounces to mL. Equation was already correct on pages 16 and 17.