1.0 Analysis for Volatiles in Liquids by Dual Column Headspace Gas Chromatography

1.1 BACKGROUND

Humans have consumed fermented beverages such as beer and wine since prehistoric times.[6] Ethanol abuse is often manifest in driving under the influence (DUI), a problem that plagues every country. The National Highway Traffic Safety Administration (NHTSA) reported that the proportion of drivers involved in fatal crashes that had a BAC of 0.08 or above decreased from 35% in 1982 to 20% in 1997 and leveled off thereafter.[17] Changes in alcohol laws and demographic changes are thought to be responsible for this positive trend. Chronic alcoholism also contributes to ethanol-related deaths. Ethanol consumed on a regular basis can lead to the development of alcoholic hepatitis which can progress into cirrhosis, liver failure, and death.[2,6,7] Chronic excessive ingestion of ethanol is directly associated with serious neurologic and mental disorders such as brain damage, memory loss, sleep disturbances and psychoses.[7] Alcohol is also involved in a high percentage of domestic disputes, many of which result in injury and/or death.

Notwithstanding a common public perception that ethanol is stimulatory, ethanol is classified as a *Central Nervous System Depressant.* Ethanol is a psychoactive drug that is similar in most respects to sedative-hypnotic compounds.[4] The first mental processes to be affected are those that depend on training and previous experience.[7] The individual's memory, concentration, and insight are dulled and subsequently lost. The person may become overly confident and exhibit uncontrolled mood swings and/or emotional outbursts.[7] The effects of ethanol and other central nervous system depressants are additive, resulting in more sedation and a greater degree of impairment in driving ability.[4]

Ethanol is rapidly and completely absorbed from the stomach, small intestine and colon. The mechanism of absorption is a simple diffusion process; alcohol moves from a region of higher concentration to a region of lower concentration.[2,4,6] Alcohol is soluble in both water and fat, a property that facilitates its diffusion through biological membranes.[4] The major amount of absorption takes place in the small intestine due to its large surface area, good blood supply and thin-walled membrane. The time from the last drink to peak concentrations can range between 30 and 90 minutes, depending upon the individual's stomach contents.[4,7] Alcohol absorption is slowed by the presence of food in the stomach. The time period required for gastric emptying is a prime factor that contributes to the wide variety of absorption rates of ingested ethanol observed in different individuals and under different conditions.[2,7] Hence, the extent of absorption in the stomach and small intestine is a function

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of the amount of ethanol at that site, the vascularity of the site and the surface area in contact with the blood supply.[2] Other factors that affect the absorption of ethanol include the type of beverage, the alcohol content, the rate of consumption and any disease state that affects normal gastric function or blood flow.[2]

Upon absorption, ethanol is distributed to all the water containing regions of the body. Within the blood system, there can be significant differences between arterial and venous blood depending upon the absorption status of the individual.[2] In the absorptive phase, the arterial blood ethanol concentration exceeds the venous blood ethanol concentration. Analysis of venous blood, therefore, underestimates the brain alcohol concentration of the individual at this point. When absorption is complete there is little difference in ethanol concentration between arterial and venous blood.[2]

Ninety to ninety-eight percent of ethanol is completely oxidized in the liver by reacting with the cofactor nicotinamide adenine dinucleotide (NAD) facilitated by alcohol dehydrogenase to produce acetaldehyde. Acetaldehyde is then acted upon by aldehyde dehydrogenase to form acetic acid which goes on to form carbon dioxide and water (figure 1). The amount of ethanol oxidized per unit time is roughly proportional to body weight and probably to liver weight. The remaining (unoxidized) alcohol is excreted unchanged in urine, expired air, saliva and sweat. The average elimination rate of ethanol is 0.015 g/dL/hour from men and 0.018 g/dL/hour for women.[2] In addition to gender, chronic abuse, prescription drugs and certain genetic factors can also influence the elimination rate.[2,6,7]

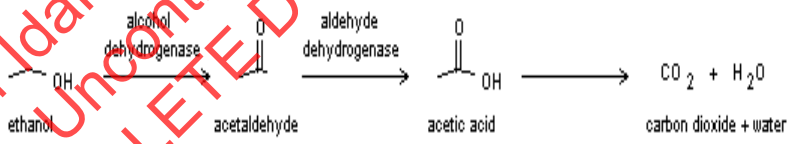

Figure 1. Metabolism of Ethanol.

Other commonly encountered toxic alcohols, alcohols other than ethanol that are not intended to be ingested, such as methanol and isopropanol, produce central nervous system (CNS) depressant effects but vary significantly in the degree.[2,18] Methanol (wood alcohol), commonly a component of model airplane fuel and windshield wiper fluid, causes relatively little intoxication compared to ethanol.[2,6,18] Its harmful effects are due to the direct result of its metabolism to formaldehyde (embalming fluid) and subsequently to formic acid. These metabolites lead to the destruction of neural cells, particularly the optic nerve, which can result in blindness.[2,6] The formic acid leads to metabolic acidosis. Isopropanol (rubbing alcohol) is more toxic than ethanol with more prominent gastritis that includes pain, nausea, vomiting and hemorrhage.[11,19] Isopropanol

is metabolized to acetone.[2,4] Note that elevated endogenous acetone may also be detected in the samples from a diabetic or fasting individual.

A variety of volatile chemicals may also be detected in samples from subjects that were inhaled either accidentally or intentionally.[15] For instance, toluene and acetone may be detected in subjects that come into contact with products such as aerosol paint and contact adhesives. The principal metabolite of toluene is benzoic acid. Chronic abuse of toluene and/or acetone can lead to organ and CNS problems that may result in permanent damage.[15] Acetone is metabolized to acetate and formate. Inhaling of electronic cleaning products referred to as computer "dusters" can result in detectable levels of the aerosol propellants 1,1-Difluoroethane (HFC-152a) and 1,1,1,2-Tetrafluoroethane (HFC-134a).[15,21] The primary consequence of abuse is cardiovascular in nature.[15]

The analysis of ethanol and other volatiles in samples of blood, vitreous humor and urine is accomplished with a gas chromatograph (GC) which uses a headspace autosampler (HSA) for sample introduction. An aliquot of sample is placed into a headspace vial along with an aqueous 1-propanol internal standard in 1M Ammonium Sulfate. The sample vials are sealed and heated in a HSA. As described in Henry's Law, in a closed container at a given temperature, a direct (proportional) relationship exists between the amount of a volatile substance dissolved in a liquid and the amount of the volatile substance in the headspace vapor above the solution. The ammonium sulfate serves as a salting-out agent, thus improving the recovery of volatiles from the headspace.[12,13,20] An aliquot of the headspace vapor is injected into a GC with a dual column configuration. The GC serves to separate out the components of the solution as a function of their chemical properties. Separated components are detected by a flame ionization detector (FID). The qualitative identification of ethanol and other common volatiles is based on the retention time determined, relative to the 1-propanol internal standard, for each of the columns. This method also provides for a quantitative determination for ethanol. The quantitative result is based on a calibration curve established by the peak area ratio between ethanol and the 1-propanol internal standard.

The need to establish the ethyl alcohol concentration and/or the presence of other commonly encountered volatiles in a beverage or solution may arise from ABC violations (Idaho Code 23-611, 23-1002, 23-1303, ...), under-age consumption (Idaho Code 23-603, 23-604), open-container violations (Idaho Code 23-505, 23-1333), poisonings and/or an endless variety of situations including questionable samples submitted as blood or other physiological fluid. In addition, ethyl alcohol concentration must be verified in simulator solutions used for breath testing instruments (IDAPA 11.03.01).

1.2 SCOPE

This method describes the Idaho State Police Forensic Services (ISPFS) procedure for the analysis of blood, vitreous humor, urine and solutions for the presence of volatile compounds. This method provides for the quantitative analysis of ethanol as well as the qualitative analysis of methanol, acetaldehyde, acetone, isopropanol, toluene, difluoroethane and related compounds, via a headspace sampling gas chromatographic method. Note that in this analytical method the terms calibrator and calibration are not used in the ISO/IEC 17025:2005 sense. The words *calibrator* and *calibration* are used to coincide with the terminology in instrument software and manufacturer manuals. The manufacturer's term *calibrator* refers to what is considered by ISP-FS as aqueous reference material that has a certified concentration of ethanol present. This aqueous reference material is used to establish a *calibration curve/table* to establish a response factor between instrument response and reference material concentration.

If this method is applied specifically for the qualitative identification of volatiles other than ethanol, ethanol calibrators and controls need not be included in the analysis run.

1.3 EQUIPMENT

1.3.1 Agilent 7890A Gas Chromatograph (GC) or equivalent, configured with a Flame Ionization Detector (FID) (Figure 2).

Figure 2. Gas Chromatograph

1.3.2 Agilent G1888, 7697 or equivalent Headspace Sampler (Figure 3).

Figure 3. G1888 Headspace Analyzer

1.3.3 Columns

1.3.3.1 Restek Rtx®-BAC1 (#18003: 30 meter X 0.32mm inner diameter (ID), 1.8µm film thickness (FT) or equivalent column)

1.3.3.2 Restek Rtx®-BAC2 (#18002: 30 meter X 0.32mm ID, 1.2 µm FT or equivalent column)

1.3.4 Headspace (HS) vials and Closures

1.3.5 Hand Crimper or Bench Top Crimper

1.3.6 Semi-Automatic Dilutor/Pipetter equipped with sample and reagent syringes capable of dispensing 250µL and 2000µL, respectively.

1.4 REAGENTS

1.4.1 Distilled/Deionized water (free from volatiles of interest)

1.4.2 Ammonium Sulfate (Certified ACS Grade)

1.5 REFERENCE MATERIAL

1.5.1 Ethanol Aqueous Reference Material

1.5.1.1 Aqueous ethanol reference material used to establish the calibration curve/table or to prepare aqueous ethanol controls can be obtained through a commercial vendor. *Aqueous reference material used to establish the calibration curve must be traceable to NIST standards.*

1.5.2 Multicomponent Volatile Aqueous Solutions

Multicomponent solutions may be purchased or prepared as indicated below.

1.5.2.1 **Commercially Obtained Multicomponent Solution**

1.5.2.1.1 Solution may include acetone, ethanol, methanol and isopropanol reference materials and/or commonly abused volatiles.

1.5.2.1.2 When the multicomponent solution contains quantitative amounts of ethanol, it may simultaneously serve as an aqueous ethanol control. The GC oven temperature program must provide for baseline separation of all components.

1.5.2.2 **Prepared Mixed Volatile Reference Solution**

1.5.2.2.1 Add approximately 250 mL of DI water to a flask. Add **one or more** of the following volatiles as needed for the qualitative identification of volatiles.

Compound	Volume
Acetaldehyde	≅100µL
Acetone	≅100µL
Ethanol	≅100µL
Ethyl Acetate	≅100µL
Methanol	≅500µL
Isopropanol	≅500µL
Toluene	≅50µL

Record preparation on reagent log. Solution is stable indefinitely when stored under refrigeration.

1.5.2.2.2 Additional volatiles of interest may be used singularly or added to the mixed volatile solution.

1.5.2.2.3 The GC oven temperature conditions must provide for baseline separation for all components placed in the mixture.

1.5.2.3 **Fluoroethane Volatile Reference Solution**

Fluoroethane reference solutions may be prepared from commercially obtained aerosol products. The product's MSDS must be obtained. Solutions may be used for as long as acceptable performance is obtained.

1.5.3 Internal Standard Solution
~0.03g/dL 1-propanol in 1.0M Ammonium Sulfate

1.5.3.1 Add 132.14g $(NH_4)_2SO_4$ per L of solution to be prepared and mix with DI water to dissolve. Add ~375µL 1-propanol per L of solution to be prepared. A maximum of 4L may be prepared at a time.

1.5.3.2 Record preparation on reagent log. Solution is stable up to 6 months.

1.6 MATRIX CONTROL MATERIAL

Refer to AM 2.0 for authentication requirements.

1.6.1 Ethanol or Multicomponent Whole Blood Control Material

1.6.2.1 A minimum of two ethanol whole blood control levels should be available, each falling within the following approximate ranges:

Level	Approximate Ethanol Range (g/100mL)
Low	0.030 – 0.130
High	0.131 – 0.400

1.6.2.2 A whole blood control containing ethanol with other volatiles can serve as a multicomponent control if the GC oven temperature program provides for baseline separation of all components.

1.7 SAFETY CONCERNS

Biological samples must be processed and chemicals handled according to safety guidelines in the *Idaho State Police Forensic Services Health and Safety Manual.*

1.8 QUALITY ASSURANCE

1.8.1 While at the laboratory samples for volatiles testing are to be stored under refrigeration. Urine samples can be either refrigerated or frozen. Urine samples submitted in plastic bottles must be frozen for long-term storage.

1.8.2 The Pipette/Dilutor must be checked for accuracy and precision. This check is performed concurrently with the establishment of the calibration curve and the use of authenticated controls during an

analysis run. There is no requirement for periodic independent performance checks for accuracy or precision as the analysis and QA/QC samples serve as a periodic check of the instruments performance.

1.8.3 Refer to Toxicology Analytical Method section 5.2 for balance intermediate check and calibration requirements.

Note: Balances properly monitored by drug discipline analysts fulfill quality assurance requirements. Additional check need not be performed.

1.8.4 Refer to manufacturer manuals for as-needed instrument maintenance procedures and troubleshooting measures.

1.8.5 Current source and lot number of controls and reference material must be documented.

1.8.6 Refer to Alcohol Analytical Method 2.0 for reference material authentication requirements.

1.8.7 Refer to Analytical Method 10.0 for quantitative ethanol reporting confidence interval/uncertainty.

1.8.8 If ethanol is not the analyte in question, a calibration curve for ethanol need not be established.

1.9 COLLECTION KIT PROCESSING

1.9.1 Collection Kit Description and Labeling

1.9.1.1 Record the following information:

1.9.1.1.1 A description of collection kit type.

1.9.1.1.2 A description of type and number of specimen collection container(s).

1.9.1.1.3 If it is apparent that the specimen container does not appear to be the one originally included in collection kit.

1.9.1.1.4 The condition of each specimen container seal.

1.9.1.1.5 The sample type (blood, urine, vitreous humor, other**.**

1.9.1.2 Laboratory number must be placed on each sample container.

1.9.1.3 When more than one sample is present, label all samples present. Use “A”, “B”, etc. or comparable in addition to the laboratory number.

1.9.2 Blood Specimen Collection Container Evaluation

1.9.2.1 Idaho Administrative Code, IDAPA 11.03.01 requires law enforcement agencies to have blood specimens, from living subjects, collected in a container containing at least *ten (10) milligrams of sodium fluoride per cubic centimeter of blood plus an appropriate anticoagulant.* [8]

1.9.2.2 The containers provided in ISPFS kits comply with IDAPA requirements. It must, however, not be assumed that an ISP-FS kit contains the specimen collection tubes it was supplied with.

1.9.2.3 Non-ISP-containers must be evaluated as to compliance. Information from the manufacturer of the container will indicate sodium fluoride concentration as well as the presence of an appropriate anticoagulant.

1.9.2.4 Note compliance of blood specimen container.

1.9.3 Blood Specimen Evaluation

1.9.3.1 IDAPA 11.03.01 requires blood to be reported as grams of alcohol per 100cc of whole blood. Although the absolute determination that the sample is whole blood is beyond the scope of this analytical method, when it is the analyst’s opinion that the intended blood sample is serum or otherwise questionable, the analyst has the following options.

1.9.3.1.1 Option One

The sample is not analyzed. A comment "Specimen unsuitable for analysis" is placed on the analysis report.

1.9.3.1.2 Option Two

The sample is analyzed for volatiles, and the report will make no mention of the sample having a biological origin.

1.10 ANALYSIS PROCEDURE

1.10.1 Calibration Curve/Table Requirements

1.10.1.1 A minimum of three ethanol aqueous reference solutions must be used to establish calibration/response factor curve.

1.10.1.2 The minimum low calibrator is to be in the nominal range of approximately 0.02 to 0.05g/100mL.

1.10.1.3 The highest calibrator concentration must be ~~a~~ 0.30g/100mL or greater.

1.10.1.4 Calibration table may be established in a separate sequence just prior to sequence containing case samples.

1.10.1.5 Ethanol calibrators should be analyzed in order of increasing concentration, and used for the generation of only one calibration curve. Calibrators should not be saved and used to generate future curves. The manufacturer's target value is defined as the manufacturer's "as prepared" certified concentration, and not the "as analyzed" value.

1.10.1.6 The least squares line resulting from the analysis of the ethanol calibrators must have a coefficient of correlation of ≥0.998.

1.10.1.7 Each ethanol calibrator may have more than one replicate.

1.10.1.7.1 In the sequence table, on the **Update RF** column, select "replace" for each of the first set of calibrators. If a second set of calibrators is run and are to be included in the generation of the calibration curve, the results are to be "averaged". (software version may differ slightly)

1.10.1.8 If data from a calibrator is not usable, the remaining data can be used to establish the response factor provided that requirements in 1.10.1.1, 1.10.1.2, 1.10.1.3 and 1.10.1.6 have been met.

1.10.1.9 A calibration curve/table is valid for 14 days, provided:

- ✓ Values for required controls fall within acceptable ranges.

- ✓ The same preparation of internal standard solution used for the calibration run is used.

1.10.1.10 Once established, analysts not involved in establishing the calibration curve/table may use the established calibration table.

1.10.1.11 The internal standard blank should immediately follow the highest ethanol calibrator.

1.10.2 Analysis Run Control and Blank Requirements

1.10.2.1 **Initial Run with Calibration Curve**
For a run with a newly established calibration curve, an ethanol containing control must precede the first 10 samples (20 vials). The control must be run in duplicate.

1.10.2.2 **Additional Runs with Existing Calibration Curve**
For analysis runs utilizing an existing calibration curve, a low and high ethanol-containing control, in duplicate, must bracket the first 10 samples before proceeding with additional samples.

1.10.2.3 **All Analysis Runs**

1.10.2.3.1 Each analysis run must contain an internal standard blank.

1.10.2.3.2 For analysis runs consisting of more than 10 case samples (20 vials), a minimum of one blood or aqueous ethanol-containing control in duplicate must be run with each additional 10 samples.

1.10.2.3.3 Each analysis run must include either an *aqueous* or *blood* multicomponent volatile mix.

1.10.2.3.4 A commercially obtained **quantitative** *multicomponent* volatile mix may serve as both an aqueous *ethanol control* and a *multicomponent mixture*.

1.10.2.3.5 Each run must contain a blood matrix control in duplicate, as defined in 1.6.2.1.

1.10.2.3.6 Each run, new or previously calibrated, must contain a traceable aqueous control in duplicate at or near the 0.080 level for control charting purposes and for an accuracy QC check. This shall be a newly opened ampoule and will be used to monitor the accuracy of the method and instrumentation over time. This sample is run as if it were a case sample and counts as if it were a case sample for control-bracketing purposes.

1.10.2.3.7 Additional aqueous controls may be run at the end of the run sequence to monitor the overall performance of the instrument, but does not need to meet the acceptance criteria set in 1.11.

1.10.2.3.8 For controls run in duplicate, the samples should contain the -A and -B designators used by the software macro for generation of the data sheet and ease of evaluation. Otherwise, the data must be put into the data sheet manually for evaluation purposes.

1.10.2.3.9 Controls of the same lot number (either aqueous or matrix control), shall not be used for multiple (different) purposes within the same run sequence. (i.e. The 0.080 aqueous control cannot be used as both an aqueous run control and the control charting control during the same run sequence).

1.10.2.4 **Qualitative only analysis runs**

Sections 1.10.1, and 1.10.2.1 - 1.10.2.3.8 do not apply for an analysis run consisting of only qualitative samples.

1.10.2.4.1 Runs consisting of only qualitative samples need only the sample in duplicate, and the volatile reference standard in question separated by an internal standard blank at a minimum.

1.10.2.4 Aqueous Controls

Lots used in the establishment of the calibration curve must not be used as aqueous controls during a run using said calibration curve.

1.10.3 Sample Preparation

1.10.3.1 Bring calibrators, controls, internal standard and samples to room temperature.

1.10.3.2 Sample preparation must take place in a laminar flow hood or biological safety cabinet.

1.10.3.3 Place blood sample container on rocker for a minimum of two minutes.

1.10.3.4 If a blood sample appears to be coagulated, the sample may require homogenization in a tissue grinder, or equivalent.

1.10.3.5 All case samples must be analyzed in duplicate.

1.10.3.6 Use Pipette/Dilutor to dispense 250µL of case sample, positive control, or calibrator solution, along with 2000µL of internal standard (ISTD), into labeled headspace vial and apply seal.

1.10.3.7 For internal standard blank, dispense 250µL of DI water along with 2000µL of internal standard (ISTD) into labeled headspace vial and apply seal.

1.10.3.8 Dilute alcoholic beverages and unknown solutions as necessary. The sample must be diluted for the value to fall within the upper limits of the calibration curve. Generally, beer and wine should be diluted ~50:1 with DI water and distilled beverages (≥ 16% w/v or 20% v/v) diluted ~100:1. If available, the dilution of unknown solutions should be based on sample history.

1.10.3.8.1 Dilution may be carried out using the autodilutor. If the autodilutor is used, the uncertainty of measurement must reflect the correct number of uses of the autodilutor in the final calculation.

1.10.3.9 Breath testing simulator solutions and samples, which appear to be serum, do not require pre-dilution.

1.10.4 Instrument Run Preparation

1.10.4.1 Open **Sequence Table.** It is recommended that each analyst create, not share, a Sequence Table. This reduces the possibility of the Sequence Table being modified without their knowledge. If a Sequence Table is shared, each analyst must inspect the Sequence prior to analysis.

1.10.4.2 In the Sequence log table, enter the sample case numbers, ethanol calibrators, volatiles single constituent reference material, volatile reference material mixtures, blank(s) and controls.

1.10.4.3 Load samples, calibrators, blank(s), reference material(s) and controls onto the headspace sampler rack as noted in the sequence table.

1.10.4.4 The sequence information should be verified prior to starting the instrument.

1.10.5 Instrument Parameters

1.10.5.1 Refer to current instrument method for gas chromatograph and headspace analyzer analysis parameters.

1.10.5.2 Analysis method must be stored centrally (hardcopy and/or electronically) each time the method parameters are updated.

1.11 CRITERIA FOR ACCEPTANCE OF DATA

1.11.1 All sample and control values must have a calibrator greater than or equal to their mean value.

1.11.2 For samples above the highest calibrator used to establish calibration curve/table, the sample must be reanalyzed after dilution. The dilution factor is incorporated into final calculations.

1.11.3 All results obtained from samples bracketed by conforming controls are acceptable for use.

1.11.4 When the overall mean of a control value falls outside of required qualitative, quantitative and/or precision acceptance criteria, the 10 casework samples preceding and following the non-conforming control(s) must be reanalyzed. If only the quantitative criteria are not met, this reanalysis requirement does not apply to samples that are being processed for the qualitative presence of volatiles other than ethanol.

1.11.5 Qualitative Accuracy Criteria

The qualitative presence of ethanol, or other volatile substances, can be established if the retention time for a specimen is within ±0.10 minutes of the retention time of the reference compound in question. This criterion should be designated in the instrument's data station analysis method.

1.11.6 Quantitative Accuracy Criteria

The quantitative ethanol results for a batch of samples can be accepted if the values obtained for control samples fall within ±10% of the manufacturer's target value. The manufacturer's target value is defined as the manufacturer's "as prepared" certified concentration, and not the "as analyzed" value.

1.11.6.1 The acceptability criteria for the control from 1.10.2.3.6 will be that the overall reported value (as if it were a casework sample) must fall within the currently accepted level for the process uncertainty of measurement as established by Blood Alcohol AM 10.0 of the target value.

1.11.7 Column Precision Criteria

1.11.7.1 The ethanol values obtained from column 1 and 2 must agree within 0.0100g/100cc (exclusive of post mortem samples).

1.11.7.1.1 For postmortem samples, if the sample fails to meet the criteria in 1.11.7.1, the analyst shall report the lowest single column result average.

1.11.7.2 If the precision requirement is not met, the sample must be reanalyzed. If upon reanalysis, the column precision requirement is not met, the source of the problem will be pursued. One possible cause is a system leak.

1.11.8 Quantitative Replicate Precision Criteria

1.11.8.1 The mean value for replicate analysis must agree as described in the following table. If the precision requirement is not met, the sample must be reanalyzed.

Results Range (g/100cc)	Precision (g/100cc)
0.0200 - 0.1099	0.0100
0.1100 - 0.2299	0.0150
0.2300 - 0.3499	0.0200
0.3500 - 0.5000	0.0300

1.11.8.2 If upon re-analysis, the replicate precision requirement for control sample(s) is not met, troubleshooting must be initiated and documented. Case samples may require additional homogenization.

1.11.8.3 If desired, a macro can be created and installed on the instrument to display the analysis data and populate it to a form/spreadsheet.

1.12 REPORTING OF RESULTS

1.12.1 General

The three decimal place truncated mean ethanol value, as determined by this method, will be reported along with the confidence interval range in the form of the uncertainty of measurement (as established by Blood Alcohol AM 10.0).

1.12.1.2 The uncertainly of measurements shall be reported out to three decimal places rounded up (+/- X.XXX)

1.12.2 Blood Ethanol Results

1.12.2.1 Report over all mean ethanol concentration, as grams of ethanol per 100cc of blood, truncated to three decimal places ± the uncertainty of measurement.

1.12.2.2 Report values <0.020g/100cc, but above 0.000 as "*below reportable limit.*". Results that are 0.000 shall be reported as "none detected".

1.12.2.3 If the sample and/or sample vial clearly does not comply with IDAPA 11.03.01, an appropriate comment must be noted on the analysis report.

1.12.3 Urine Ethanol Results

1.12.3.1 The four decimal place over all mean ethanol value must first be multiplied by 0.67.

1.12.3.2 Report over all mean ethanol value as grams of ethanol per 67mL of urine truncated to three decimal places ± uncertainty of measurement.

1.12.3.3 Report values <0.020g/67ml, but above 0.000 as "*below reportable limit.*". Results that are 0.000 shall be reported as "none detected".

1.12.3.4 A qualifier statement "*Urine results may be of questionable value"* **must** be included in the analysis report for ethyl alcohol determination.[8] The disclaimer is not required for other volatiles reported qualitatively.

1.12.4 Vitreous Humor Ethanol

1.12.4.1 Report over all mean ethanol concentration, as grams of ethanol per 100cc of vitreous humor, truncated to three decimal places (0.000) ± uncertainty of measurement.

1.12.4.2 Report values <0.020g/100cc, but above 0.000 as "*below reportable limit."*. Results that are 0.000 shall be reported as "none detected".

1.12.4.3 No conversion to a blood alcohol value will be made on the report.

1.12.5 Alcohol Beverages

1.12.5.1 To obtain the ethanol concentration value, the overall mean ethanol concentration results are multiplied by the dilution factor (if applicable). This will provide the ethanol concentration in g/100cc (weight per volume (w/v) percent).

1.12.5.2 For volume per volume (v/v) value, divide w/v value by 0.79.

1.12.5.3 Value must be reported as both w/v and v/v percent. The mean value must be truncated and reported out to the tenths decimal place ± the uncertainty of measurement

1.12.6 Unknown Liquids and "Serum" - Ethanol

1.12.6.1 Report ethanol concentration in g/100cc and/or weight per volume (w/v) percent, depending on the sample history.

1.12.6.2 When dilution is necessary, the overall mean results of analysis must be multiplied by the dilution factor.

1.12.6.3 When reporting as g/100cc, report over all mean ethanol concentration, truncated to three decimal places (0.000), as grams of ethanol per 100cc of liquid ± the uncertainty of measurement.

1.12.7 Reporting of Qualitative Volatiles Results

The qualitative presence of other volatiles such as acetone, isopropyl alcohol, methyl alcohol, toluene and formaldehyde will be noted on the analysis report following the ethyl alcohol results, if present.

1.12.8 Comments for Analysis Report

As appropriate and/or required, comments outlining actions, discrepancies and/or qualifiers can be included on the analysis report following the results of analysis.

1.12.9 Breath Testing Solutions

Provide results to Discipline Leader for evaluation.

1.13 ANALYSIS DOCUMENTATION

1.13.1 Volatiles Analysis Forms

1.13.1.1 Spreadsheet form for calibrator, controls and case sample can be located under I:\ALCOHOL\BLOOD\Blood Control QA

1.13.2 Quality Assurance Data

1.13.2.1 A copy of quality assurance data (calibrators and controls) need not be included in individual case files.

1.13.2.2 A packet containing spreadsheets and data for response factor/calibration curve, controls and reference material will be prepared for each analysis run and stored centrally in the location designated for alcohol quality assurance data in the laboratory where the analysis was performed until archiving.

1.13.2.2 The storage of central data may be done electronically.

1.13.2.3 When necessary, a copy of the quality assurance data can be prepared from the centrally stored documents or reprinted from electronically stored data.

1.13.2.4 For qualitative only runs, the only QA samples that need to be included are the qualitative reference standard used to identify the peaks of interest and the appropriate blanks (internal standard and optional water blank).

1.14 MAINTENANCE

1.14.1 Consult the instruments maintenance manual for types of maintenance available for this instrument.

1.14.2 It is required that a cleaning or "baking" method be developed in each laboratory that is specific for the instrument. The baking procedure should increase the temperatures of the samples pathway through the instrument.

1.14.2.1 The cleaning method is to be run on an "as needed" basis that is dictated by the analyst. The indicators include but are not limited to, changes in the peak shape, baseline noise, column precision, and retention time drift.

1.14.2.1 G1888 headspace/7890A GC parameters example:
HS Oven Temp: 100ºC
Loop Temp: 200ºC
Transfer Line Temp: 200ºC
Inlet Temp: 220ºC (for BAC1/BAC2 columns)
GC Oven Temp: 220ºC (for BAC1/BAC2 columns)
Detector Temp: 250ºC

1.14.3 On a yearly basis, all of the data files and calibration curve data will be backed up to permanent media, or equivalent backup device.

1.15 REFERENCES AND RECOMMENDED READING

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Revision History

1.0 Quantitative Analysis for Ethanol and Qualitative Analysis for Other Volatiles in Blood, Vitreous Humor and Urine by Dual Column Headspace Gas Chromatography

Revision #	Issue Date	Revisions
0	10/2001	Initial version.
1	05-15-2002	Clarifications, coefficient of correlation change for system compatibility.
2	09-13-2002	Addition of analysis documentation section.
3	01-03-2003	Clarifications, refinement of analysis documentation section 1.10.
4	04-06-2004	Clarifications, acceptance criteria and quality assurance sections amended, authentication guidelines added.
5	06-16-2004	Addition to section 1.8.5.3. Modification of 1.8.11.4 (*duplicate* replaced with *replicate*)
6	12-29-2005	Modified format, updated and clarified quality assurance requirements.
7	05-07-2007	Updated QA measures, nomenclature and formatting.
8	08-20-2008	Updated for new instrumentation. Deviation in place prior to this date. Made running an internal standard blank following the high blood control an option instead of a requirement (1.7.3.2.2). Added uncertainty language. Clarified and consolidated sections.
9	09-07-2009	Clarified uncertainty and QA wording. Updated background, scope and references. Authentication section moved to AM 5.14.
0	01-20-2011	Initial version as 1.0, split from toxicology discipline analytical methods. Formerly AM 4.1. Clarified QA requirements.

1	8-23-2011	Combined Alcohol AM 1.0 rev 0 and 2.0 rev 0 to include analysis of Volatiles in liquids. Changes made to reflect changes in other AM's. I.S. requirements were changed.
2	04-23-2012	Changes made to reflect correct references to other AM's. 1.12.5.3 changed to reflect more accurate reporting of alcoholic beverage type values. Added 1.11.2.3.6. Removed 1.10.1.11.
3	06-11-2012	Added recommended maintenance to section 1.14, clarified calibrator usage in 1.10.1.5. Edited 1.11.7.1 and added 1.11.7.1.1. Changed 1.12.2.2, 1.10.2.2, 1.10.2.3.2, 1.10.2.3.6, 1.10.2.3.7, 1.11.4, 1.11.6.1, 1.11.8.1, 1.11.8.3, 1.12.2.2, 1.12.3.3, 1.12.5.3, 1.12.5.1, and clarified 1.12.3.4. Reformatted prior section 1.14 to be section 1.15.
4	1-16-2013	Changes made to sections 1.8.2, 1.10.1.7.1, 1.10.2.1, 1.10.2.3.6, 1.10.3.5, 1.10.3.8, 1.11.4, 1.11.6.1, 1.12.1, 1.12.2.1, 1.12.3.1, 1.12.4.1, 1.12.6.2, 1.12.6.3, 1.13.2.3. Sections 1.10.2.3.8 and 1.13.2.2 were added.
5	3-8-2013	Section 1.10.2.4, 1.10.2.4.1 were added to clarify qualitative analysis runs. Section 1.14.3 added for electronic data backup schedule.
6	1/16/2014	Section 1.9, 1.9.2.4, 1.12 were edited.
7	4/22/2015	Changes were made to sections 1.6.2.1, 1.10.2.1, 1.10.2.2, 1.10.2.3.5, 1.10.2.3.6, 1.10.2.3.9, 1.10.2.4, 1.10.3.8.1, 1.11.2, and 1.11.6