Training Outline for the Examination of Fire Debris Evidence

1.0 Purpose – This document provides an outline for training in the examination of fire debris evidence, including the requisite competency testing.

2.0 Scope – This training outline shall be followed by all trainees in the examination of fire debris evidence, regardless of experience level.

3.0 Module I – Preparation for Analysis of Fire Debris Samples

3.1 Objectives: Through completion of this module, the trainee shall have developed and demonstrated the theoretical knowledge and/or practical skills in:

3.1.1 Evidence handling, evidence collection, evidence packaging, and chain of custody for fire debris-related evidence. The ability to recognize and preserve other items of potential evidentiary value.

3.1.2 Basic organic chemistry as it relates to fire debris analysis.

3.1.3 The petroleum refining process, the ASTM classification scheme, petroleum products inherent to common matrices, and terminology used in the field of fire debris analysis as well as that used in the petroleum industry.

3.1.4 Basic fire science and investigation techniques including: basic concepts, terminology, nomenclature, chemistry of combustion, fire dynamics, fire modeling, practical aspects of scene investigation, aspects of evidence collection, and the use of canine units.

3.1.5 The extraction techniques utilized in fire debris analysis and the advantages and disadvantages of each.

3.2 Reading Assignments

3.2.1 State Crime Laboratory Evidence Guide.

3.2.2 Current NCSCL procedures related to the examination of fire debris evidence, GC-FID and GC-MS.

3.2.3 *Kirk's Fire Investigation (Fourth Edition or later)*, Elementary Chemistry of Combustion Chapter.

3.2.4 Newman, Reta; Gilbert, Michael; Lothridge, Kevin. *GC/MS Guide to Ignitable Liquids*. New York: CRC Press, 1998.

3.2.5 NFPA 921.

3.2.6 Stauffer, Eric; Dolan, Julia; Newman, Reta. *Fire Debris Analysis*. San Diego: Elsevier, Inc., 2008.

3.2.7 ASTM Guidelines

3.2.7.1 ASTM Standard E1386, Current, "Standard Practice for Concentration of Ignitable Liquid Residues from Fire Debris Samples by Solvent Extraction." ASTM International, West Conshohocken, PA, 2001, www.astm.org.

3.2.7.2 ASTM Standard E1387, Current, "Standard Test Method for Ignitable Liquid Residues in Extracts from Fire Debris Samples by Gas Chromatography." ASTM International, West Conshohocken, PA, 2001, www.astm.org.

3.2.7.3 ASTM Standard E1388, Current, "Standard Practice for Sampling of Headspace Vapors from Fire Debris Samples." ASTM International, West Conshohocken, PA, 2000, www.astm.org.

3.2.7.4 ASTM Standard E1412, Current, "Standard Practice for Separation of Ignitable Liquid Residues from Fire Debris Samples by Passive Headspace Concentration with Activated Charcoal." ASTM International, West Conshohocken, PA, 2001, www.astm.org.

3.2.7.5 ASTM Standard E 1413, Current, "Standard Practice for Separation and concentration of Ignitable Liquid Residues from fire Debris Samples by Dynamic Headspace Concentration." ASTM International, West Conshohocken, PA, 2006, www.astm.org.

3.2.7.6 ASTM Standard E1618, Current, "Standard Test Method for Ignitable Liquid Residues in Extracts from Fire Debris Samples by Gas Chromatography – Mass Spectrometry." ASTM International, West Conshohocken, PA, 2006, www.astm.org.

3.2.8 Published Journal Articles

3.2.8.1 Bertsch, W., and C.S. Sellers, "Limits in Arson Debris Analysis by Capillary Column Gas Chromatography/Mass Spectrometry." *HRC CC Journal of High Resolution Chromatography & Chromatography Communications* 9.11 (Nov. 1986): 657-661.

3.2.8.2 Buckleton, J.S., B.L. Bettany and K.A.J. Walsh. "A Problem of Hydrocarbon Profile Modification by Charcoal." *Journal of Forensic Sciences* 34.2 (1989): 449-453.

3.2.8.3 Demers-Kohls, J.F., S.L. Ouderkirk, J.L. Buckle, W.E. Norman, N.S. Cartwright and C. Dagenais. "Evaluation of the D-FLEX Device for Fire Debris Analysis." *Canadian Society of Forensic Science Journal* 27.3 (1994): 99-123.

3.2.8.4 Dietz, W.R. "Improved Charcoal Packaging for Accelerant Recovery by Passive Diffusion." *Journal of Forensic Sciences* 36.1 (1991): 111-121.

3.2.8.5 Frenkel, M., S. Tsaroom, Z. Aizenshtat, S. Kraus and D. Daphna. "Enhanced Sensitivity in Analysis of Arson Residues: An Adsorption-Tube/Gas Chromatograph Method." *Journal of Forensic Sciences* 293 (1984): 723-731.

3.2.8.6 Furton, K.G., J.R. Almirall, and J.C. Bruna. "A Novel Method for the Analysis of Gasoline From Fire Debris Using Headspace Solid-Phase Microextraction." *Journal of Forensic Sciences* 41.1 (1996): 12-22.

3.2.8.7 Hirz, R. "Gasoline Brand Identification and Individualization of Gasoline Lots." *Journal of the Forensic Science Society* 29.2 (1989): 91-101.

3.2.8.8 Mann, D.C. "Comparison of Automotive Gasolines Using Capillary Gas Chromatography I: Comparison Methodology." *Journal of Forensic Sciences* 32.3 (1987): 606-615.

3.2.8.9 Mann, D.C. "Comparison of Automotive Gasolines Using Capillary Gas Chromatography II: Limitations of Automotive Gasoline Comparisons in Casework." *Journal of Forensic Sciences* 32.3 (1987): 616-628.

3.2.8.10 Mann, D.C. and W.R. Gresham. "Microbial Degradation of Gasoline in Soil." *Journal of Forensic Sciences* 35.4 (1990): 913-923.

3.2.8.11 Midkiff, C.R., Jr. "Is It a Petroleum Product? How Do You Know?" *Journal of Forensic Sciences* 31.1 (1986): 231-234.

3.2.8.12 Newman, R.T., W.R. Dietz and K. Lothridge. "The Use of Activated Charcoal Strips for Fire Debris Extractions by Passive Diffusion. Part 1: The Effects of Time, Temperature, Strip Size, and Sample Concentration." *Journal of Forensic Sciences* 41.3 (1996): 361-370.

3.2.8.13 Phelps, J.L., C.E. Chasteen and M.M. Render. "Extraction and Analysis of Low Molecular Weight Alcohols and Acetone From Fire Debris Using Passive Headspace Concentration." *Journal of Forensic Sciences* 39.1 (1994): 194-206.

3.2.8.14 Reeve, V., J. Jeffery, D. Weihs and W. Jennings. "Developments in Arson Analysis: A Comparison of Charcoal Adsorption and Direct Headspace Injection Techniques Using Fused Silica Capillary Gas Chromatography." *Journal of Forensic Sciences* 31.2 (1986): 479-488.

3.2.8.15 Saferstein, R. and S.A. Park. "Application of Dynamic Headspace Analysis to Laboratory and Field Arson Investigations." *Journal of Forensic Sciences* 27.3 (1982): 484-494.

3.2.8.16 Tontarski, R.E., Jr. "Evaluation of Polyethylene Containers Used to Collect Evidence for Accelerant Detection." *Journal of Forensic Sciences* 28.2 (1983): 440-445.

3.2.8.17 Tontarski, R.E., Jr. "Using Absorbents to Collect Hydrocarbon Accelerants From Concrete." *Journal of Forensic Sciences* 30.4 (1985): 1230-1232.

3.3 Exercises

3.3.1 Read literature pertaining to this module.

3.3.2 Perform casework with qualified Forensic Scientists. This shall involve in-depth participation including note taking, sample selection, sample preparation, evidence handling and marking, and odor detection, as well as selection and preparation of extraction procedures (Solvent Extraction, Adsorption/Elution (DFLEX), Heated Headspace and Neat).

3.3.3 Introduction to GC-FID and GC-MS and related software

3.3.3.1 Work one-on-one with an experienced Forensic Scientist to review basic data analysis features.

3.3.3.2 Use previously acquired library data to integrate chromatograms, take spectra, search spectra, create a reconstructed ion profile, and run macros.

3.3.4 Samples for Analysis

3.3.4.1 Spike three cans with a 50/50 mixture of gasoline and a heavy petroleum distillate. Extract one can by headspace analysis, one by adsorption/elution, and one by solvent extraction. Run the extracts and a neat sample on the GC-MS. Discuss results, listing the advantages and disadvantages of each method of sample preparation and its effect on the resulting chromatogram.

3.3.5 Attend an Accelerant Detection Canine training session, if possible

3.4 Evaluation

3.4.1 Successfully complete a written examination to evaluate proficiency with Module I.

3.4.2 Successfully complete a practical examination covering the extraction and classification of a minimum of 3 unburned debris samples (at least one of which is negative) utilizing heated headspace, solvent extraction, and/or adsorption / elution (DFLEX) methods.

4.0 Module II – Analysis and Interpretation of Fire Debris Samples

4.1 Objectives: Through completion of this module, the trainee shall have developed and demonstrated the theoretical knowledge and/or practical skills in:

4.1.1 Basic chromatographic theory and its applications to gas chromatography.

4.1.2 The identification and function of components of a gas chromatograph.

4.1.3 The operation of gas chromatographs in the Trace Unit.

4.1.4 The performance of QA/QC procedures and routine maintenance on a GC-FID and GC-MS including troubleshooting.

4.1.5 The basic theory and proficient use of the Mass Spectrometer for fire debris analysis.

4.1.6 Potential resources available, including personnel, scientific literature and anarchist literature.

4.1.7 The identification and classification of bulk ignitable liquids and ignitable liquid residues from data obtained from the GC-FID and GC-MS and recognition of patterns of common pyrolysis products and other interfering matrices.

4.2 Reading Assignments

4.2.1 Appropriate Instrument Manuals.

4.2.2 In-house validation study (2014) for extracting ethylene glycol by passive-adsorption elution using charcoal strips eluted with acetone.

4.2.3 Newman, Reta, Michael Gilbert, and Kevin Lothridge. *GC-MS Guide to Ignitable Liquids*. New York: CRC Press, 1998.

4.2.4 ASTM Guidelines

4.2.4.1 ASTM Standard E1387, Current, "Standard Test Method for Ignitable Liquid Residues in Extracts from Fire Debris Samples by Gas Chromatography." ASTM International, West Conshohocken, PA, 2001, www.astm.org.

4.2.4.2 ASTM Standard E1618, Current, "Standard Test Method for Ignitable Liquid Residues in Extracts from Fire Debris Samples by Gas Chromatography – Mass Spectrometry." ASTM International, West Conshohocken, PA, 2006, www.astm.org.

4.2.5 Published Journal Articles

4.2.5.1 Armstrong, A.T. and R.S. Wittkower. "Identification of Accelerants in Fire Residues by Capillary Column Gas Chromatography." *Journal of Forensic Sciences* 23.4 (1978): 662-671.

4.2.5.2 Karkkainen, M., I. Seppala and K. Himberg. "Detection of Trace Levels of Gasoline in Arson Cases by Gas Chromatography-Mass Spectrometry with an Automatic On-Line Thermal Desorber." *Journal of Forensic Sciences* 39.1 (1994): 186-193.

4.2.5.3 Kelly, R.J. and R.M. Martz. "Accelerant Identification in Fire Debris by Gas Chromatography/Mass Spectrometry Techniques." *Journal of Forensic Sciences* 29.3 (1984): 714-722.

4.2.5.4 Keto, R.O. and P.L. Wineman. "Detection of Petroleum-Based Accelerants in Fire Debris by Target Compound Gas Chromatography-Mass Spectrometry." *Analytical Chemistry* 63.18 (1991): 1964-1971.

4.2.5.5 Mach, M.H. "Gas Chromatography-Mass Spectrometry of Simulated Arson Residue Using Gasoline as an Accelerant." *Journal of Forensic Sciences* 22.2 (1977): 348-357.

4.2.5.6 Nowicki, J. "An Accelerant Classification Scheme Based on Analysis by Gas Chromatography-Mass Spectrometry (GC-MS)." *Journal of Forensic Sciences* 35.5 (1990): 1064-1086.

4.2.5.7 Nowicki, J. "Analysis of Fire Debris Samples by Gas Chromatography-Mass Spectrometry (GC-MS): Case Studies." *Journal of Forensic Sciences* 36.5 (1991): 1536-1550.

4.2.5.8 Nowicki, J. "Automated Data Analysis of Fire Debris Samples Using Gas Chromatography-Mass Spectrometry and Macro Programming." *Journal of Forensic Sciences* 38.6 (1993): 1354-1362.

4.2.5.9 Smith, R.M. "Arson Analysis by Mass Chromatography." *Analytical Chemistry* 54.13 (1982): 1399A-1409A.

4.2.5.10 Smith, R.M. "The Mass Chromatographic Analysis of Arson Accelerants." *Journal of Forensic Sciences* 28.2 (1983): 318-329.

4.3 Exercises

4.3.1 Read literature pertaining to this module.

4.3.2 Perform casework with qualified Forensic Scientists (assisting with extractions, setting up the autosampler, etc.).

4.3.3 Introduction to use of GC-MS.

4.3.3.1 Work one-on-one with an experienced Forensic Scientist to perform and interpret the auto-tune and examine its parameters.

4.3.3.2 Work one-on-one with an experienced Forensic Scientist to learn how to produce, run and interpret a QC standard, check it for quality compliance, and to record QC data properly in the appropriate log book.

4.3.4 Demonstrate competency in use of GC-FID and GC-MS hardware and software.

4.3.5 Demonstrate competency in interpretation of GC-FID and GC-MS data.

4.3.6 Demonstrate competency in routine maintenance and quality assurance procedures (e.g. calibration, tuning, and use of standards).

4.3.7 Assist a senior Forensic Scientist in maintenance of the Mass Spectrometer, performing various maintenance activities including changing septa, changing columns, cleaning detectors, changing gas cylinders and others as needed.

4.3.8 Samples for Analysis

4.3.8.1 Using a neat gasoline TIC, label the following peaks: toluene, ethylbenzene, m-, p- and o-xylene, C_3-alkylbenzenes, C_4-alkylbenzenes, indane, naphthalene, and 1-and 2-methylnaphthalene.

4.3.8.2 Compare laboratory standards of gasoline in several stages of weathering (for example: 90 %, 75 %, 50 %, 25 %, 10 %, 5 % and 2 % residual). If needed, perform weathering of any depleted laboratory standards to replenish the reference collection. Add new weathered standards to the instrument library.

4.3.8.3 Using a neat diesel fuel TIC, label the visible n-alkanes, pristane and phytane.

4.3.8.4 Analyze 2 neat samples from each of the following classifications: LPD, MPD, and HPD.

4.3.8.5 Compare laboratory standards of distillates in several stages of weathering as determined by training officer. If needed, perform weathering of any depleted laboratory standards to replenish the reference collection. Add new weathered standards to the instrument library.

4.3.8.6 Analyze a minimum of 3 samples which are best suited for headspace analysis, such as acetone, methanol, 2-propanol or MIBK.

4.3.8.7 Analyze extractions from a minimum of 5 types of materials that may have inherent petroleum products. Materials shall be analyzed in both pristine and charred states.

4.3.8.8 Obtain, analyze and classify a minimum of 10 additional products for the ignitable liquid reference collection.

4.3.9 Analyze unknown sets of samples provided by the training officer.

4.3.9.1 Practical Set 1 – Classify a minimum of 5 neat samples of petroleum-based products using the GC-FID and/or GC-MS. These do not require extraction.

4.3.9.2 Practical Set 2 – Classify a minimum of 5 neat samples that are more complex than the previous set using the GC-FID and/or GC-MS. This may include miscellaneous-class ignitable liquids or easily distinguished mixtures. These do not require extraction.

4.3.9.3 Practical Set 3 – Analyze and interpret a minimum of 3 samples comprised of unburned substrates, some of which may be spiked with a known ignitable liquid. These samples shall require the use of an extraction procedure and shall be analyzed using the GC-FID and/or GC-MS.

4.3.9.4 Practical Set 4 – Analyze and interpret a minimum of 3 samples of oxygenated and/or single compound products, which shall be identified using the GC-MS. One of these samples shall be ethylene glycol.

4.3.9.5 Practical Set 5 – Analyze and interpret a minimum of 5 samples comprised of a variety of charred matrices, some of which may be spiked with a known ignitable liquid. These samples shall require the use of an extraction procedure and shall be analyzed using the GC-FID and/or GC-MS.

4.4 Evaluation

4.4.1 Successfully complete a written examination to evaluate proficiency with Module II.

4.4.2 Successfully complete an oral examination that shall include explaining instrumentation in both layman and scientific terms. Also complete this in writing for future reference.

4.4.3 Successfully complete a practical examination requiring the classification of a minimum of 5 unknown samples.

5.0 Module III – Casework and Courtroom Preparation

5.1 Objectives: Through completion of this module, the trainee shall have developed and demonstrated the theoretical knowledge of and/or practical skills to:

5.1.1 Successfully complete a case from assignment to defense.

5.1.2 Write a clear, accurate and concise laboratory report consistent with Laboratory and Section guidelines.

5.1.3 Describe courtroom procedures.

5.1.4 Effectively present the results of a fire debris examination in court.

5.1.5 Describe the legal and ethical obligations of an expert witness.

5.1.6 Describe the admissibility standards set by *Daubert* and *Frye*.

5.2 Reading Assignments

5.2.1 CVs or Statements of Qualifications of other Forensic Scientists.

5.2.2 *Daubert v. Merrill Dow Pharmaceuticals,* 509 U.S. 579 (1993).

5.2.3 *Frye v. United States,* 293 F. 1013 (DC Cir. 1923).

5.2.4 Ron Smith and Associates, Inc. "Courtroom Testimony Techniques: Success Instead of Survival." Collinsville, Mississippi.

5.2.5 Feder, H.A. and M.M. Houck. *Succeeding as an Expert Witness*. 4th ed. Boca Raton: CRC Press, 2008.

5.2.6 ASTM Guidelines

5.2.6.1 ASTM Standard E1387, Current, "Standard Test Method for Ignitable Liquid Residues in Extracts from Fire Debris Samples by Gas Chromatography." ASTM International, West Conshohocken, PA, 2001, www.astm.org.

5.2.6.2 ASTM Standard E1618, Current, "Standard Test Method for Ignitable Liquid Residues in Extracts from Fire Debris Samples by Gas Chromatography – Mass Spectrometry." ASTM International, West Conshohocken, PA, 2006, www.astm.org.

5.2.7 Published Journal Articles

5.2.7.1 Kantrowitz, S.B. "Expert Testimony and Scientific Evidence in Arson-Related Cases." *Journal of Forensic Sciences* 26.1 (1981): 142-152.

5.2.7.2 Kogan, J.D. "On Being a Good Expert Witness in a Criminal Case." *Journal of Forensic Sciences* 23.1 (1978): 190-200.

5.2.7.3 Philipps, K.A. ""The Nuts and Bolts" of Testifying as a Forensic Scientist." *Journal of Forensic Scientists* 22.2 (1977): 457-463.

5.2.7.4 Tanton, R.L. "Jury Preconceptions and Their Effect on Expert Scientific Testimony." *Journal of Forensic Sciences* 24.3 (1979): 681-691.

5.3 Exercises

5.3.1 Read literature pertaining to this module.

5.3.2 Continue to perform casework with qualified Forensic Scientists.

5.3.3 Prepare or update a CV or Statement of Qualifications reflective of experience in fire debris examination.

5.3.4 Prepare a series of qualifying questions and answers to those questions for use in a voir dire.

5.3.5 Observe pretrial conferences and courtroom testimony of qualified Forensic Scientists, if possible.

5.4 Evaluation

5.4.1 Successfully complete a written comprehensive examination to evaluate overall proficiency in fire debris analysis.

5.4.2 Based on evidence for a mock case (including some items that may present challenges in reporting such as softwoods, shoes, clothing or mixtures of individual solvents), generate an entire case record and draft a report with accurate conclusions.

5.4.3 Using the mock case, successfully complete a moot court or roundtable discussion.

6.0 Records

- Training file
- Training checklist

7.0 Attachments – N/A

Revision History		
Effective Date	Version Number	Reason
09/17/2012	1	Original ISO Document
10/18/2013	2	Added issuing authority to header; 4.2.2 - removed repeated word
08/29/2014	3	• Updated header to Physical Evidence Section – Trace Unit, issuing authority to Physical Evidence Section Forensic Scientist Manager. • Changed procedure name to Training Outline for the Examination of Fire Debris Evidence • Changed all references of "arson" to "fire debris" • Edited 3.3.5
12/11/2015	4	Added Stauffer book and NCSCL fire debris procedures to 3.2 Changed ASTM publish dates to "Current" in 3.2.5, 4.2.3 & 5.2.6 Changed GC-FID to GC-MS in 3.3.4.1 Changed Section to Trace Unit in 4.1.3 Add ethylene glycol validation study to 4.2 Clarified training requirements in 4.3.8 Renamed unknown sets in 4.3.9.1 – 4.3.9.5 Changed "different liquid" to "neat" in 4.3.9.1 and 4.3.9.2 Added "and interpret" and ethylene glycol requirement to 4.3.9.4 Added written requirement to 4.4.2