DIVISION OF INVESTIGATIVE & FORENSIC SERVICES

BUREAU OF FORENSIC SERVICES

FIRE DEBRIS ANALYSIS INTERN TRAINING PROGRAM

Version 20120515

Overview of Training for Interns in Fire Debris Analysis

The program contains numerous readings, lectures, and shadowing of an assigned mentor that are designed to provide an intern with theoretical and historical knowledge of fire debris analysis and to a lesser extent fire scene investigation. While this training will provide a solid background in fire debris analysis it is in no means sufficient by itself to prepare an intern for independent fire debris analysis. The forensic laboratory that hires the intern on a full time basis will undoubtedly have its own procedures and protocols which the intern will need to adapt.

This program is designed to work concurrently within an active laboratory. The intern will begin working on the program while actively participating in the laboratory. They will observe experienced analysts preparing, analyzing, and interpreting debris samples. During the intern's first few weeks, they are also to read and become familiar with the laboratory's "Guidelines for Collection, Packaging and Submission of Evidence". As their proficiency improves, their mentors may allow them to have more hands on work in these areas. The mentor may assign additional readings as well. The intern will be expected to propose, plan, justify, and execute a research project during their time at BFFEA. They will make a presentation on their project at the end of their time in the internship. The intern should be able to show their proficiency with completion of a comprehensive oral examination at the end of their internship period.

The Lecture Modules

Module 1: Investigation Of The Scene And Collection Of Evidence For Forensic Analysis

Historical Development
Myths
IAAI
ASTM
NFPA921
TWGFEX
Tools
Training the modern investigator

This section will cover those issues affecting the selection of samples sent to the laboratory for analysis and will discuss pertinent authoritative references that can be used by analysts in guiding field investigators. Many investigators are unaware of the myths surrounding selection of samples for forensic analysis (spalling, crazed glass, "hot" fires, etc... and may benefit from guidance from the laboratory to make better selection of samples. This section will familiarize analysts with where to find guidance on: selection of unknowns and comparison samples: collection methods, packaging requirements, and preservation of fire debris evidence.

Module 2: Basic Fire Dynamics and How It Affects Forensic Evidence

Essential Definitions
Ignition Temperature
Flash Point
Fire Point
Flammable/Explosive Limits
Heat Transfer
Convection
Conduction
Radiation
Fuels
Pyrolysis

This section will discuss the dynamics of fire and how it affects ignitable liquids and matrices within the scene. In particular, the deterioration of ignitable liquids and the production/nature of pyrolysis products will be covered. The affect of fire on other types of forensic evidence will also be briefly discussed.

Module 3: Fire Modeling

An overview of fire modeling as a tool in fire scene investigation will be addressed briefly.

Module 4: Ignitable Liquids: Petroleum Products

Petroleum Refining Processes

- Distillation
- Cracking
- Reforming
- Isomerization
- Alkylation
- Gasoline Production and Reformulation

This section will provide an overview of the process of petroleum refining and the production of commercial products that could be used as ignitable liquids. A discussion of marketing and labeling with examples will be provided.

Module 5: Ignitable Liquids: Non-Petroleum Products

This section will discuss commercial products that are not derived directly from the petroleum process, but may be employed as accelerants. These will include turpentine, specialty solvents, low molecular weight solvents (alcohols and ketones) and their availability.

Module 6: Sources of Ignitable Liquids in the Fire Scene

- Accelerants
- Background
  - Ignitable Liquids Inherent to a Matrix
  - Pyrolysis Products

This section will discuss whether an ignitable liquid found could be an "accelerant" or if its presence could be due to its isolation from matrices or pyrolysis of matrices in the scene. The need for a determination of which ignitable liquids were used in the scene and when they were used will be discussed to emphasize a close connection to the scene investigator.

Module 7: Classification System: Development

- National Bureau of Standards
- International Association of Arson Investigators
- American Society for Testing and Materials (ASTM)
  - E1412
  - E1618

This section will correlate the previous discussions on the petroleum refinery products and non-petroleum products with the recognition and development of a standardized method for extracting and classifying those products. It will emphasize the currently accepted system and a statistical breakout of one laboratory's experience since 1992 (over 63,000 samples).

Module 8: Classification System: ASTM Guidelines

Gasoline
Distillates

This section will focus on the requirements for identification of the two most common classes of ignitable liquids found. The discussion will review examples of the classes via internet connection to the TWGFEX database.

Module 9: Classification System: ASTM Guidelines

Isoparaffinic Products
Normal Alkane Products
Aromatic Solvents
Naphthenic/Paraffinic Solvents
Oxygenated Products
Miscellaneous:
- Specialty Solvents
- Blended Products
- Isolated Chemicals

This section will focus on the requirements for identification of the remaining classes of ignitable liquids. The discussion will review examples of the classes via internet connection to the TWGFEX database.

Module 10: Practical Exercises

The practical exercises will focus on the correct classification for standards from each class.

Module 11: Recovering Ignitable Liquids from Submitted Evidence: Types of Submissions

Liquids
Surfaces
Clothing
Tissue
Debris

This section will discuss the types of materials that may be submitted for identification of ignitable liquids and will discuss potential problems encountered with each type of evidence. Methods for mitigation of problems will be discussed.

Module 12: Recovering Ignitable Liquids from Submitted Evidence: Extraction Methodologies

Standardization of Techniques
- National Bureau of Standards

International Association of Arson Investigators
American Society for Testing and Materials (ASTM)

Distillation - Steam & Vacuum
Solvent Wash
Headspace:
- Simple (Heated and Ambient)
- Dynamic
- Passive

Solid Phase Microextraction

This section will cover the development of the various ASTM recognized extraction methodologies and will discuss the advantages and disadvantages of each technique. A multi-disciplinary approach will be evaluated for those items and situations that may require the use of a technique not normally employed by the student.

Module 13: Gas Chromatography Refresher

- Brief History
- Essentials
- Injection and Injectors
  - Split
  - Splitless
  - On-Column
  - As a thermal desorption device
  - Manual
  - Automated
- Columns
  - Packed v. Capillary
  - Length
  - Coating
  - Carrier
  - Separation and Resolution
- Detectors
  - Universal
  - Thermal Conductivity
  - Flame Ionization
  - Mass Spectral

This section will serve as a brief overview of gas chromatography and the importance of standardization of the parameters for normal operation of the GC will be covered. Variations in operation that may be made in order to enhance certain analyses or troubleshoot difficult samples (depending on desired results) will be discussed.

Module 14: Types of MS Detectors

Quadrupoles
Ion Traps
Advantages and Disadvantages

This section will focus on more detail as to the function and operation of common benchtop mass spectral detectors. Operating parameters as well as advantages and disadvantages of the different types will be covered.

Module 15: Potential Instrumentation Applicable to Analysis of Ignitable Liquids

GC/MS^n
GC x GC - FID and MS
FT Ion Cyclotron MS
Stable Isotope Ratio MS

This section will discuss instrumental developments in ignitable liquid analysis. Current development of a GC/MS/MS standard for ASTM and the various parameters and limitations of the technique will be discussed. Available research into other new instrument applications will be evaluated so that students will have a better understanding of their potential for the future.

Module 16: Basic Organic Chemistry of Ignitable Liquid Compounds

This section will further identify the organic chemicals present in ignitable liquids and will discuss their oxidation reactions that will affect their recovery. The section will also cover the chemical reactions occurring during pyrolysis of matrix materials and the production of additive compounds that can affect interpretation.

Module 17: GC/MS Fragmentation of Organic Compounds

This section will focus on the expected fragmentation of organic molecules during mass spectral analysis. Methods for using the mass spectra to identify or confirm the unknown molecules will be covered

Module 18: Interpretation of GC/MS Data: Starting with the Total Ion Chromatogram

This section will cover the basic observation that all interpretation of data begins with pattern matching and identification. Examples of total ion chromatograms will be shared and the information that can be derived from them (particularly regarding the abundance and ratios of compounds) will be discussed.

Module 19: Interpretation of GC/MS Data: Reconstructed Ion Chromatograms (Ion Profiling)

Summed Ions
Single Ion

This section will discuss the use of instrumental software to provide both summed and single ion chromatograms of unknowns. The student will be taught to recognize when the data presented from these techniques are sufficient and when

additions information may be required. The student will learn how to use this data to begin their interpretation of what may be present in the sample.

Module 20: Interpretation of GC/MS Data: Target Compounds (2 hours)

Spectral Interpretation
Significance
Using a Systematic Approach (Swimcharting)

A systematic method for diagnosing the data from GC/MS analysis will be presented. This section will provide examples where the identification of ignitable liquids through spectral, retention time, and ratio comparisons of both single and summed ion profiles can be used to make a valid interpretation.

Module 21: Practical Exercises in Interpretation

The practical exercises will focus on the correct classification of unknowns that will be chosen from ignitable liquid classes as well as recognition of negative samples (primarily pyrolysis products and patterns generated by compounds inherent to various matrices).

Module 22: Quality Assurance

This section will cover requirements for assuring that extracts prepared and data collected is free from extraneous interferences that could compromise the opinion of the analyst. Record keeping and archival of materials will be discussed.

Module 23: Report Writing

This section will discuss the minimum information that is required in a report and will discuss additional information which may be included that would make the report more understandable. The wording of the findings (both positive and negative) as well as the inclusion of disclaimers in the report will be discussed.

Module 24: Expert Testimony/Communication

This section will emphasize that the value of good science and exemplary analysis is moot if the analyst cannot translate their findings into words that can be understood by the lay person. Communication basics such as body language, being objective, clarity of tone, and hypothetical situations will be discussed.

Bibligraphy of suggested readings:

Module 1

1. Lentini JJ, Fultz ML, Armstrong A, Davis B, DeHaan J, Henderson R, et al. Forensic Science Committee Position on Comparison Samples. Fire and Arson Investigator 1990; 41(2): 50-1.
2. Bennett GD. Physical Evidence in Arson Cases. J Crim Law, Criminal, and Police Sci 1953; 44: 652-60.
3. Adams DL. The Extraction and Identification of Small Amounts of Accelerants from Arson Evidence. J Crim Law, Criminal, and Police Sci 1956; 47: 593-6.
4. DeHaan JD. Fire engineering, Fire Investigation, and the Forensic Scientist. Sacramento: California Criminalistics Institute, 1995.
5. State of Florida Department of Financial Services Division of State Fire Marshal Bureau of Forensic Fire and Explosives Analysis: Guide to the Collection, Packaging, Submission, and Analysis of Evidence Current Version.
6. ASTM International. E 1188-current version: Standard Practice for Collection and Presentation of Information and Physical Items by a Technical Investigator.
7. ASTM international. E1459- current version: Standard Guide for Physical Evidence Labeling and Related Documentation. 2005.
8. Chapter 16: Physical Evidence. Fire and Explosion Investigations 2008; 921: 134-43

Module 2

1. Gardiner, Jr. WC. The Chemistry of Flames.
2. DeHaan JD. The Dynamics of flash Fires Involving Flammable Hydrocarbon Liquids. J Forensic Medicine and Pathology 1996; 17(1): 24-31.
3. Chapter 5: Basic Fire Science. Fire and Explosion Investigation 2008; 921: 18-39
4. Henry CL. Study of Nylon Bags for Packaging Fire Debris. The CACNews 2008: 30-2.
5. Hüthig. Chemical analysis for the Asron Investigator and Attorney. 169-70.
6. Federal Emergency Management Agency, United States Fire Administration, National Fire Academy. Arson Detection for the First Responder. FEMA/USFA/NFA-ADFR-SM July 1996: 4-37 – 4-38.
7. NFPA. NFPA 921 Guide for Fire and Explosion Investigation 1998 Edition: 14-6.

Module 3

1. Madrzykowski D. Fire Modeling in Scene Investigation (PowerPoint slides). Fire Research division, Building and Fire Research Lab: National Institute of Standards and Technology.
2. Madrzykowski D. The Future of fire Investigation. Fire Chief 2000: 44-50.

Module 4

1. Johnson MM. Petroleum Products and Processes. 1-36.
2. Kuk FJ, Spagnola MV. Extraction of Alternative Fuels from Fire Debris Samples. J forensic Sci 2008; 53(5): 1123-9.
3. Haggin J. New Refinery Process Aims to Reduce Benzene. C & EN September 1993: 37.
4. Reese K. Crackers: How Refiners Learned to Wring More Gas from Crude. Today's Chemist at Work November/December 1993: 56-60.
5. Aromatics in Reformulated Gasoline by GC/MS. The Restek Advantage: 6.

Module 5

1. Jackowski JP. The Incidence of Ignitable Liquid Residues in Fire Debris as Determined by a Sensitive and Comprehensive Analytical Scheme. J Forensic Sci 1997; 42(5): 828-32.
2. Exxon Chemical. LVP Solvents: Replacements for D-Limonene Cleaning Products.

Module 6

1. Ask the Scientist
2. Lentini JJ, Dolan JA, Cherry C. The Petroleum-Laced Background. J Forensic Sci 2000; 45(5): 968-989.
3. Lowry WT, Juarez L, Petty CS, Roberts B. Studies of Toxic Gas Production during Actual Structural Fires in the Dallas Area. J Forensic Sci 1985; 30(1): 59-72.
4. Lowry WT, Peterson J, Petty CS, Badgett JL. Free Radical Production from Controlled Low-Energy Fires: Toxicity Considerations. J Forensic Sci 1985; 30(1): 73-85
5. IAAI Forensic Science Committee. Fire Debris Analysis: Is Your Lab Giving You Proper Results?.

Module 7

1. Forensic Science & Engineering Committee. Guidelines for Laboratories Performing Chemical and Instrumental Analyses of fire Debris Samples. International Association of Arson Investigators March 19--: 45-7.
2. Ettling BV. Analysis of Paraffin Wax in Fire Remains. J Forensic Sci 1975; 20(3): 476-83.
3. Midkiff Jr. CR and Washington WD. Gas Chromatographic Determination of Traces of Accelerant in Physical Evidence. Journal of The AOAC 1972; 55(4): 840-5.
4. Chisum WJ and Elzerman TR. Identification of Arson Accelerants by Gas Chromatographic Patterns Produced by a Digital Log Electrometer. J Forensic Sci 1972; 17(2): 280-91.

5. Blackledge RD. The Recovery and Identification of Flammable Liquids in Suspected Arsons: An undergraduate organic experiment. J Chem Ed 1974; 51: 549-50.
6. Yip IHL and Clair EG. A Rapid Analysis of Accelerants in Fire Debris. Can Soc Forensic Sci J 1976; 9(2): 75-80.
7. Standard Test Method For: Flammable or Combustible Liquid Residues in Extracts from Samples of Fire Debris by Gas Chromatography. Fire and Arson Investigator: 51-4.
8. Lentini JJ. Fire Debris Analysis: Evolution and Standardization of Techniques (slides). TWGFEX Symposium 2004.

Module 8

1. ASTM International. E 1618- current version: Standard Test Method for Ignitable Liquid Residues in Extracts from Fire Debris Samples by Gas Chromatography-Mass Spectrometry. 1-11.
2. Bertsch W. Interpretation of GC/MS Data (syllabus and handouts). 1-30.
3. Locke AK, Basara GJ, and Sandercock PML. Evaluation of Internal Standards for the Analysis of Ignitable Liquids in Fire Debris. J Forensic Sci 2000; 54(2): 320-7.
4. Wallace JR. GC/MS Data from Fire Debris Samples: Interpretation and Application. J Forensic Sci 1999; 44(5): 996-1012.
5. Smith RM. Arson Analysis by Mass Chromatography. The Analytical Approach.
6. Youngless TL, Swansiger JT, Danner DA, and Greco M, Mass Spectral Characterization of Petroleum Dyes, Tracers, and Additives. Analytical Chemistry 1985; 57(9).
7. Cain PM. Comparison of Kerosenes Using Capillary Column Gas Liquid Chromatography. J Forensic Sci 1975; 15: 301-8.

Module 9

1. Koussiafes P and Bertsch W. Profile Matching for the Analysis of Accelerants in Suspected Arson Cases. Journal of Chromatographic Science 1993; 31: 137-44.

Module 11

1. DeHaan JD. Pyrolysis Products of Structure fires. J Forensic Sci 1988; 28: 299-309.
2. Clodfelter RW and Hueske EE. A Comparison of Decomposition Products from Selected Burned Materials with Common Arson Accelerants. Criminalistics Lab Ft. Worth Police Department.
3. IAAI Forensic Science Committee. Are ignitable liquid residues sometimes incidental to certain samples? How should this affect the investigator and the interpretation of the laboratory report?. 2005.

4. IAAI Forensic Science Committee. The Effects of Surfactants and Microbes on the Identification of Ignitable Liquids under Aerobic Conditions in Fire Debris. 2005.

Module 12

1. ASTM International. E 1386- current version: Standard Practice for Separation and Concentration of Ignitable Liquid Residues from Fire Debris Samples by Solvent Extraction. 2005.
2. ASTM International. E 1388- current version: Standard Practice for Sampling of Headspace Vapors from Fire Debris Samples.
3. ASTM International. E 1412- current version: Standard Practice for Separation of Ignitable liquid Residues from Fire Debris Samples by Passive Headspace Concentration with Activated Charcoal.
4. ASTM International. E 1413- current version: Standard Practice for Separation and Concentration of Ignitable Liquid Residues from Fire Debris Samples by Dynamic Headspace Concentration.
5. ASTM International E 2154- current version: Standard Practice for Separation and Concentration of ignitable Liquid Residues from fire Debris Samples by Passive Headspace Concentration with Solid Phase Micro extraction (SPME). 2008.
6. Stafford Jr. GC, Kelley PE, and Bradford DC. Advanced Ion Trap Technology in an Economical Detector for GC. American Laboratory 1983.
7. Sandercock PML. Comparison of Passive Charcoal Adsorption with a Dynamic Charcoal Adsorption Technique. Can Soc Forensic Sci J 1994; 27(3): 179-201.
8. Reeve V, Jeffery J, Weihs D, and Jennings W. Developments in Arson Analysis: A Comparison of Charcoal Adsorption and Direct Headspace Injection Techniques Using Fused Silica Capillary Gas Chromatography. J Forensic Sci 1986; 31(2): 479-88.
9. Tontarski RE and Strobel RA. Automated Sampling and Computer Assisted Identification of Hydrocarbon Accelerants. J Forensic Sci 1982; 27(3): 710-4.
10. Higgins KM, Higgins MK, Oakes CL, and Braverman SF. High-Speed Extraction of Accelerants from Arson Debris. J Forensic Sci 1984; 29(3): 874-80.

Module 13

1. Allison J and Stepnowski RM. The Hows and Whys of Ion Trapping. Instrumentation.
2. Self Chemical Ionization in an Ion Trap Mass Spectrometer. Anal Chem 1988; 60: 2312-4.
3. Pannell LK, Pu QL, Fales HM, Mason RT, and Stephenson JL. Intermolecular Processes in the Ion Trap Mass Spectrometer. Anal Chem 1989; 61(22): 2500-3.

Module 14

1. Majors RE. The Rise and Fall of Expertise in Gas Chromatography. LCGC North American 2006; 24(5): 448-57.
2. Split Injection packet
3. Direct Injection packet
4. Eiceman GA, Clement RE, and Hill Jr. HH. Gas Chromatography. Anal Chem 1992; 64: 170-80.

Module 16

1. Rodgers RP, Blumer EN, Freitas MA, and Marshall AG. Compositional Analysis for Identification of Arson Accelerants by Electron Ionization Fourier Transform Ion Cyclotron Resonance High-Resolution Mass Spectroscopy. J Forensic Sci 2001; 46(2): 268-79.
2. Frysinger GS and Gaines RB. Comprehensive Two-Dimensional Gas Chromatography for Analysis of Ignitable Liquids (PowerPoint Slides). Department of Science U.S. Coast Guard Academy 2004.
3. ASTM International. Standard Guide for Identification of Ignitable Liquid Residues in Extracts from Fire Debris Samples by Gas Chromatography/Mass Spectrometry/Mass Spectrometry (GC/MS/MS). 3-35.
4. Barshick SA. Analysis of Accelerants and Fire Debris Using Aroma Detection Technology. J Forensic Sci 1998; 43(2): 284-93.
5. Bryce KL, Stone IC, and Daugherty KE. Analysis of Fire Debris by Nuclear Magnetic Resonance Spectroscopy. J Forensic Sci 1981; 26(4): 678-85.

Modules 16 & 17

1. Appendix A: Masses and Isotopic Abundance Ratios for Various Combinations of Carbon, Hydrogen, Nitrogen and Oxygen. 41-67.
2. Appendix B: Common Fragment Ions. 68-71.

Modules 18, 19, & 20

1. Keto RO and Wineman PL. Detection of Petroleum-Based Accelerants in Fire Debris by Target Compound Gas Chromatography/Mass Spectroscopy. Anal Chem 1991; 63: 1964-71.
2. Smith RM. Arson Analysis by Mass Chromatography. The Analytical Approach.
3. Phelps JL, Chasteen CE, and Render MM. Extraction and Analysis of Low Molecular Weight Alcohols and Acetone from Fire Debris Using Passive Headspace Concentration. J Forensic Sci 1994; 39(1): 194-206.

Module 22

1. Ask the Scientist. IAAI 2006
2. Trimpe M and Chasteen C. Comparing Gasoline Samples in the Forensic Laboratory. IAAI Forensic Science Committee.
3. ASTM International. E 1020-03: Standard Practice for Reporting Incidents that may involve Litigation.
4. Bendell N. Pointers for Witnesses. 1973; 30(4): 1.
5. Pierce. Ten Commandments for an Expert Witness. Engineers Institute 1961: 178.
6. Cantor BJ. The Expert Witness. 1967; 32(2): 1-2.
7. Common Tactics of Cross-Examination.
8. Common Tactics of Defense Counsel.
9. Court Deposition(s) Copy