

**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<sup>n</sup>  
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.

## **Bibliography 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.
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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.
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### 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?.

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#### 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.
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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*.
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## 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.
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#### Module 14

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2. Split Injection packet
3. Direct Injection packet
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#### Module 16

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#### 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

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## Module 22

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4. Bendell N. Pointers for Witnesses. 1973; 30(4): 1.
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8. Common Tactics of Defense Counsel.
9. Court Deposition(s) Copy