

Idaho State Police
Forensic Services
Pocatello Laboratory

Fire Evidence Training Manual





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Section 1. Training Objectives

This manual is intended as a guide to introduce a forensic analyst to the many aspects of fire evidence analysis. The manual first addresses issues such as how fire evidence is received into the laboratory, how to write up the results of an analysis and how to safely use the necessary solvents. The main goal of this manual is to prepare the analyst to recover and identify ignitable liquids in fire related evidence. In order to understand and correctly interpret the analytical data generated, various sections will also address the chemistry and physics of fire, petroleum refining and the classification of ignitable liquids. For the fire chemist to be a resource for fire investigators, the manual has sections dealing with the determination of origin and cause and the collection and packaging of fire related evidence.

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Section 2. Evidence Handling

2.1 Fire Evidence Intake

The trainee should demonstrate an understanding of the procedures followed for the intake of fire samples and subsequent specimen handling considerations.

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2.2 References

- 2.2.1. Pocatello Forensic Services TRS manual
- 2.2.2. ASTM E 1459-92, Standard Guide for Physical Evidence Labeling and Related Documentation.
- 2.2.3. ATF Laboratories/NFSTC, Basic Fire Debris Course, Section Covering **Case Management**.

2.3 General familiarization with the fire evidence analysis program

The trainee should demonstrate an understanding of the agencies served and the programs that the fire chemist is involved with.

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2.4 References

- 2.4.1. Idaho's Canine Accelerant Detection Program Manual.
- 2.4.2. Fire Chiefs List.

Section 3. Safety Issues

- 3.1 Solvent Use**
To include an understanding of the safety hazards associated with the use of carbon disulfide and pentane.

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- 3.2 References**
- 3.2.1. *ASTM D 752, Standard Practice for Safety and Health Requirements Relating to Occupational Exposure to Carbon Disulfide.*
 - 3.2.2. Material safety data sheets (MSDS) for carbon disulfide and pentane.
 - 3.3.3. ATF Laboratories/NFSTC, Basic Fire Debris Course, Section Covering Safety.

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Section 4. Review of Relevant Principles of Organic Chemistry

4.1 Terminology, Nomenclature and Structures

4.1.1. The trainee will demonstrate a practical understanding of the terminology, nomenclature, physical properties and structures involved with petroleum chemistry.

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4.2 References

4.2.1. Basic Current Organic Chemistry Text

4.2.2. Basic Current College Chemistry Text

4.2.3. Elementary Chemistry of Combustion, Chapter 2 pp. 7-17. *in:* Kirks's Fire Investigation, 4th edition, 1997.

4.2.4. Olah, G.A. and Molnar, A. *Hydrocarbon Chemistry*, Wiley-Interscience, New York, 1995.

Section 5. Chemistry and Physics of Fire

5.1 Familiarization with the Basic Elements of Fire Behavior.

- 5.1.1. The trainee should demonstrate an understanding of the following: fire triangle versus fire tetrahedron, the three modes of heat transfer and the phases of the burning process.
- 5.1.2. Define the phenomenon of fire, describe each of the four classifications of fire.

5.2 Fire Chemistry Terminology

- 5.2.1. Define the terms flammability range, explosive range, ignition temperature. Describe the interdependence of these terms.
- 5.2.2. Define the terms flash point, flammable liquid, combustible liquids, flammable and British thermal unit (BTU).
- 5.2.3. Describe the phenomena of flashover and backdraft.

5.3 Pyrolysis Products

- 5.3.1. The trainee should display a familiarization of the pyrolysis products produced during the combustion of fuel sources at the fire scene.

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5.4 References

- 5.4.1. Elementary Chemistry of Combustion, Chapter 2 pp. 7-17. *in*: Kirks's Fire Investigation, 4th edition ,1997.
- 5.4.2. The Nature and Behavior of Fire, Chapter 3 pp. 18-39. *in*: Kirks's Fire Investigation, 4th edition ,1997.
- 5.4.3. Combustion Properties of Liquid and Gaseous Fuels, Chapter 4 pp. 66-88. *in*: Kirks's Fire Investigation, 4th edition, 1997.
- 5.4.4. Combustion Properties of Solid Fuels, Chapter 5 pp. 66-88. *in*: Kirks's Fire Investigation, 4th edition, 1997.
- 5.4.5. ATF Laboratories/NFSTC, Basic Fire Debris Course, Section Covering *Chemistry and Physics of Fire*.

- 5.4.6. DeHaan, J.D. and Bonarius, K. *Pyrolysis Products of Structure Fires*, J. For. Sci Soc, 28(5/6):299-309, 1988.
- 5.4.7. Clodfeller, R.W. and Hueske, E.E. A Comparison of Decomposition Products from Selected Burned Materials with Common Arson Accelerants, J. For. Sci, 22(1): 116-118, 1977.

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Section 6. The Refining of Petroleum

6.1 Refinery Processes

- 6.1.1. The trainee will obtain an insight into petroleum refinery operations and processes.
- 6.1.2. The trainee will have an understanding of the relationship between the refinery processes and the petroleum products that are produced.
- 6.1.3. Describe the molecular types found in petroleum.

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6.2 References

- 6.2.1. ATF Laboratories/NESTC, Basic Fire Debris Course, Section Covering *Petroleum Refinery*.
- 6.2.2. Basic Current Organic Chemistry Text
- 6.2.3. Olah, G.A. and Molnar, A. *Hydrocarbon Sources and Separation*, pp. 4-8, *in: Hydrocarbon Chemistry*, Wiley-Interscience, New York, 1995.
- 6.2.4. Olah, G.A. and Molnar, A. *Petroleum Refining and Upgrading*, pp. 10-11, *in: Hydrocarbon Chemistry*, Wiley-Interscience, New York, 1995.
- 6.2.5. Olah, G.A. and Molnar, A. *Hydrocarbons from Petroleum and Natural Gas*, pp. 28-55 *in: Hydrocarbon Chemistry*, Wiley-Interscience, New York, 1995.

Section 7. Methods for the Recovery of Ignitable Liquids from Fire Evidence and Practical Exercise

- 7.1 Historical Perspective.**
7.1.1 Trainee must demonstrate an appreciation of historical development of current recovery techniques.
- 7.2 Solvent Extraction Recovery Technique**
7.2.1 Knowledge to include an understanding of the principle, the limitations of, and the applications of this recovery technique.
7.2.2 Knowledge of ASTM E E1386-96, Standard Practice For Separation and Concentration of Ignitable Liquid Residues by Solvent Extraction.
7.2.3 Discuss the adage “*Like-Dissolves-Like*” as it applies to fire debris analysis.
- 7.3 Charcoal Strip Static Adsorption Technique**
7.3.1 Includes an understanding of the principle, the limitations of, and the applications of this recovery technique.
7.3.2 Knowledge of ASTM E 1412-95, Standard Practice for Separation and Concentration Ignitable Liquid Residues from Fire Debris Samples by Passive Headspace Concentration.
7.3.3 Define the following terms: Adsorption, Desorption.
7.3.4 Describe the forces and mechanism involved with the physical adsorption process
7.3.5 Discuss the parameters that affect the physical adsorption recovery process.

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7.4 Sample Preparation Techniques Practical Exercise

7.4.1 Trainee must successfully complete exercise.

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7.5 References

- 7.5.1 ATF Laboratories/NFSTC, Basic Fire Debris Course, Section Covering **Historic Evolution of Fire Debris Analysis**.
- 7.5.2 ATF Laboratories/NFSTC, Basic Fire Debris Course, Section Covering **Adsorption 101**.
- 7.5.3 ATF Laboratories/NFSTC, Basic Fire Debris Course, Section Covering **Sample Preparation Techniques – Practical Exercise #2**.
- 7.5.4 Idaho State Police – Forensic Services Manual: *Separation, Concentration and Analysis of Ignitable Liquid Residues from Fire Evidence Samples*
- 7.5.5 ASTM E 1387-95, Standard Test Method for Ignitable Liquid Residues in Extracts from Fire Debris Samples by Gas Chromatography.
- 7.5.6 ASTM E 1618-94, Standard Guide for Ignitable Liquid Residues in Extracts from Fire Debris Samples by Gas Chromatography-Mass Spectrometry.
- 7.5.7 ASTM E 1386-96, Standard Practice For Separation and Concentration of Ignitable Liquid Residues from Fire Debris Samples by Solvent Extraction
- 7.5.8 ASTM E 1412-95, Standard Practice for Separation and Concentration of Ignitable Liquid Residues from Fire Debris by Passive Headspace Concentration.
- 7.5.9 NFSTC Advanced Fire Debris Analysis Course Student Manual, Section Covering **Analysis Protocols and Proficiency Testing in Fire Debris Analysis**.

Section 8. Instrumental Method of Analysis: GC/MS

- 8.1 Basic theory of gas chromatography utilizing a mass selective detector.**
8.1.1 The trainee will demonstrate an understanding of the theories associated with gas chromatography and mass spectrometry.
- 8.2 General operation and maintenance of HP 5890/5971 GC/MS.**
8.2.1 The trainee will demonstrate their ability to operate and maintain the GC/MSD. This is to include familiarity with the Chem Station software, source and inlet maintenance and troubleshooting techniques.
- 8.3 Reasons for GC/MS in Fire Evidence Analysis**
8.3.1 The analyst will describe why GC/MS is preferable over GC/FID for fire evidence analysis.
8.3.2 Define the groups of ions used for extracted ion profile for each compound type.
- 8.4 Familiarization with and use of Extracted Ion Macros.**
8.4.1 Demonstrate an understanding of the application of extracted ion Macros to interpret mass spectral data.

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8.5 References

- 8.5.1 ATF Laboratories/NFSTC, Basic Fire Debris Course, Section Covering **Mass Spec Overview.**
- 8.5.2 NFSTC Advanced Fire Debris Analysis Course Student Manual, Section Covering **Mass Spectrometry Theory.**
- 8.5.3 NFSTC Advanced Fire Debris Analysis Course Student Manual, Section Covering **Instrumental Methods of Analysis.**

Section 9. Classification of Petroleum Products/Ignitable Liquids

9.1 Ignitable Liquid Classification System

9.1.1 Trainee will demonstrate an understanding of the ignitable liquid classification system and its applications.

9.1.2 Give examples of the products in each ignitable liquid class.

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9.2 References

9.2.1 Newman, R., Gilbert, M. and Lothridge, K., *GC-MS Guide to Ignitable Liquids*, CRC Press, New York, 1998.

9.2.2 ATF Laboratories/NFSTC, Basic Fire Debris Course, Section Covering **Mass Spec Overview**.

9.2.3 NFSTC Advanced Fire Debris Analysis Course Student Manual, Section Covering **Petroleum Products**.

9.2.4 NFSTC Advanced Fire Debris Analysis Course Student Manual, Section Covering **Mass Spectrometry Data Interpretation**.

9.2.5 ASTM E 1387-95, Standard Test Method for Ignitable Liquid Residues in Extracts from Fire Debris Samples by Gas Chromatography.

9.2.6 ASTM E 1618-94, Standard Guide for Ignitable Liquid Residues in Extracts from Fire Debris Samples by Gas Chromatography-mass Spectrometry.

Section 10. Interpretation of Data and Practical Exercises

- 10.1 Describe the minimum criteria that must be met to characterize an extract as containing a particular class of ignitable liquid, for each of the six classes (classes 1-5 and class 0 {0.1-0.4}) of ignitable liquids.
- 10.2 Discuss the proper approach to the interpretation of GC/MSD data.

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10.3 **Interpretation of Data Practical Exercise**

10.3.1 Trainee must successfully complete exercises #3: Real World Samples and #4: Difficult Samples in ATF Laboratories/NFSTC, Basic Fire Debris Course.

10.3.2 Trainee must successfully complete practical exercises #1: Classification, and #2: Real World Samples, in NFSTC Advanced Fire Debris Analysis Course Student Manual.

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10.4 **References**

10.4.1 ATF Laboratories/NFSTC, Basic Fire Debris Course, Section Covering **Analysis of Real World Samples**

10.4.1 ATF Laboratories/NFSTC, Basic Fire Debris Course, Section covering **Chromatographic Interpretation**

10.4.2 NFSTC Advanced Fire Debris Analysis Course Student Manual, Section Covering **Practical Exercise #3, Real World Samples.**

10.4.1 Newman, R., Gilbert, M. and Lothridge, K., *GC-MS Guide to Ignitable Liquids*, CRC Press: New York, 1998.

Section 11. Proficiency Testing

11.1 Internal.
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11.2 External.
Date assigned: _____ Date completed: _____

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11.3 References

11.3.1 ATF Laboratories/NFSTC, Basic Fire Debris Course,
Section covering **Proficiency Testing**

11.3.2 NFSTC Advanced Fire Debris Analysis Course Student
Manual, Section Covering **Analysis Protocols and
Proficiency Testing in Fire Debris Analysis.**

Section 12. Preparation and Presentation of Courtroom Testimony

12.1 Moot Court

12.1.1. The trainee will participate in moot court with laboratory personnel serving as the prosecuting and defense attorneys.

12.2 Courtroom Appearances

12.2.1. Discuss appropriate eye contact, gestures, voice volume, and approach for visual aides during testimony.

12.2.2. Describe proper attire for courtroom appearances.

12.3 Admission of Evidence

12.3.1 Discuss the ramifications of *Daubert v. Merrell Dow Pharmaceutical*.

12.3.2 List the factors that help assure a scientific testing procedure to be established as reliable.

12.4 References

12.4.2 NFSTC Advanced Fire Debris Analysis Course Student Manual, Section **Covering Expert Testimony/Preparation for Testimony.**

12.4.1 Sannito, T., *Nonverbal Communications in the Courtroom*, Champion, Sept.-Oct., 1985.

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Section 13. Determination of Origin and Cause

13.1. Cause and Origin

- 13.1.1 The analyst will develop an understanding of the approach fire investigators take in the determination of cause and origin.
- 13.1.2 Describe the factors and indicators used by fire investigators when determining the origin of a fire.
- 13.1.3 Discuss the potential causes of a fire that are considered by the fire investigator.

13.2 Protection of Fire Scene Indicators

- 13.2.1 Define what is meant by *overhaul* of a fire scene. Discuss why selective overhaul by fire personnel is crucial for reconstruction purposes.

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13.3 References

- 13.3.1 ATF Laboratories/NFSTC, Basic Fire Debris Course, Section covering **Cause and Origin**
- 13.3.2. *Sources of Ignition*, Chap. 6, pp. 89-126.. *in*: Kirks's Fire Investigation, 4th edition ,1997.
- 13.3.3. *Structure Fires and Their Investigation*, Chap. 7, pp. 127-199. *in*: Kirks's Fire Investigation, 4th edition ,1997.
- 13.3.4. O'Connor, J.J. *Practical fire and Arson Investigations*, New York: Elsevier, 1987.

Section 14. Collection and Packaging of Fire Related Evidence

14.1 Fire Sample Nomenclature

- 14.1.1 Describe the types of samples submitted in fire cases.
- 14.1.2 Describe what types of comparison samples are useful in fire casework.

14.2 Proper Collection and Packaging

- 14.2.1 Trainee will demonstrate an understanding of proper collection and packaging techniques for fire evidence.
- 14.2.2 Discuss acceptable choices of containers for the packaging of fire evidence.
- 14.2.3 Describe the advantages and disadvantages of the approved evidence containers.
- 14.2.4 Describe the best ways to avoid contamination when collecting fire evidence.

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14.3 References

- 14.3.1 ISP - Forensic Services, Physical Evidence Manual for Fire Investigators, 1999.
- 14.3.2 ATF Laboratories/NFSTC, Basic Fire Debris Course, Section covering **Collection and Packaging of Evidence**.
- 14.3.3 Ryneanson, J.M. *The Arson Scene*, in: Evidence and Crime Scene Reconstruction, 5th ed., National Crime Investigation and Training: California, 1997.

Additional References (I will be listing these at a later date)

In Fire Evidence Analysis Binder:

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In Reference Manual from NFTSC Advanced Fire Debris Analysis Course:

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Manual History

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Technical Leader

David A. Laycock
David A. Laycock

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QC Manager

Richard D. Groff
Rick Groff

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