Training Guidelines for the Fire Debris Analyst

Lesson Plan (Module) 4

Date: November 2006 **Instructor:** Qualified Instructor

Subject: Effects of Fire **Total Time:** 12 hours

Learning Objectives

- Understand the effects of heat and fire including melting, evaporation, distillation, pyrolysis and combustion.
- Understand and predict the effects of evaporation and combustion on ignitable liquids.
- Describe the process of pyrolysis as it applies to solid fuels.
- List pyrolysis products commonly encountered in fire debris containing ordinary combustibles.
- Understand the effects and possible contributions of chemicals used in fire suppression

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Suggested Reading

1. *Kirk's Fire Investigation*, 5th Edition, John DeHaan, Ed. Brady/Prentice Hall, Upper Saddle River, NJ, 2002, ISBN:0130604585, Chapters 2-5.
2. *The Chemical History of a Candle*, M. Faraday. Dover Publications, 2002 (Reprint) ISBN:04864254.
3. *NFPA 921, Guide for Fire and Explosion Investigation*. NFPA, Quincy, MA. 2004, Chapters 5 and 6.
4. "Baseline Characteristics of Residential Structures Which Have Burned to Completion: The Oakland Experience." Lentini, JJ, Smith, DM, and Henderson, RW *Fire Technology*, 28, August 1992.
5. "Basic concepts of pyrolysis for fire debris analysts." Eric Stauffer. *Science and Justice*, 43(1), pp29-40, 2003.
6. *Fire Suppression Practices and Procedures*. E. Mahoney, Brady Publishing, Englewood Cliffs, NJ, 1992.
7. "The effects of surfactants and microbes on the identification of ignitable liquids in fire debris analysis." D. Byron, *Fire and Arson Investigator*, 53(1), p.50, 2002.
8. "The possible contamination of fire scenes by the use of positive pressure ventilation fans." T. Lang and BM Dixon. *Canadian Society of Forensic Sciences Journal*, 33(2), pp. 55-60, 2000.
9. *Ignition Handbook*, Babrauskas, V., Fire Science Publishers, Issaquah, WA, 2003. (See for specific reference data.)

10. “The effect of compressed air foam on the detection of hydrocarbon fuels in fire debris samples”, Coulson, SA, et al., *Science and Justice* 40(4), pp. 257-260, 2000.

Introduction

This lesson will cover the effects of heat and fire on various fuels and how they relate to the interpretation of laboratory results. The effects of fire suppression techniques on fire debris evidence will also be discussed.

Outline

1. Effects of heat and fire
   a. melting
   b. evaporation
   c. distillation
   d. pyrolysis
   e. combustion

2. Effects of evaporation and combustion of ignitable liquids
   a. single component liquids
   b. multi-component liquids
   c. immiscible liquids

3. Pyrolysis processes of fuels
   a. physical conditions - surface temperatures, melting (thermoplastic), thermal degradation (thermosetting, elastomers)
   b. petroleum products – waxes, asphalts, polymers
   c. non-petroleum products – wood, natural fibers, biological materials
   d. pyrolysis of liquids

4. Thermal degradation products from ordinary combustibles
   a. physical processes - distillation (terpenes, water)
   b. chemical mechanisms and products - (styrene, alkenes, aromatics, fatty acids, alcohols)

5. Fire Suppression
   a. foams
   b. positive pressure ventilation
   c. dry chemicals
   d. remediation agents
   e. equipment

Teaching Aids

Handout
PowerPoint presentation
Practical exercises

Summary

Laboratory analysis of fire debris can reveal a wide range of volatile products and less volatile residues produced by the effects of heat, fire, and suppression methods on materials present in the fire scene. These effects can range from simple melting, evaporation, and distillation to pyrolysis (thermal degradation) and combustion. The fire debris analyst must be familiar with the results of these processes on common household products as well as ignitable liquids. The analyst must be able to understand the basic physical and chemical processes, including pyrolysis, and interpret the effects of evaporation and combustion on solid and liquid fuels. The analyst must also understand how the fire and evidence recovery processes affect separation and characterization techniques.

Test Questions:

1. The primary route of fire control when foam is applied to a fire is by:

   a. cooling
   b. interruption of chemical process
   c. **exclusion of air**
   d. dilution

2. The vapor pressure curve of a liquid can be used to determine its:

   a. freezing point
   b. boiling point
   c. flammability range
   d. a and b
   e. **b and c**

3. The effects of combustion on component ratios in a multi-component liquid fuel can be distinguished from the effects of simple evaporation. True or **False**

4. Thermosetting polymers undergo reversible melting without chemical degradation. True or **False**

5. Pyrolysis is the thermally induced degradation of a material into simple molecules without interaction with oxygen. **True** or False

6. Flaming combustion of nearly all solid fuels requires pyrolysis to occur first. **True** or False

7. The first pyrolysis products generated by heating wood include water, terpenes and methanol. True or **False**