

Training Guidelines for the Fire Debris Analyst

Basic Training Requirements as Set Forth by TWGFEX Lab Fire/Arson Training and Education Committee

Introduction:

These guidelines are intended as a training tool for all levels of fire debris analysts. This document is an outline of essential topics for fire debris analysts to study throughout their career. The needs and requirements of each individual laboratory will determine the implementation of each topic within these guidelines. Nevertheless, it is the intent of this document to list expected knowledge, skills and abilities for each topic and to reinforce these by suggested literature, practice techniques and testing mechanisms.

1. Chemistry and Physics of Fire

- **Knowledge:**

Basic understanding of fuels and combustion to include flames, smoldering, combustion products, heat release rates, heat fluxes, ignition temperatures, flash points, flammability ranges, spontaneous combustion, flashover, etc.

- **Skills and Abilities:** N/A

- **Example Resources:**

- Literature

- Kirk's Fire Investigation, 4th edition chapters 2 through 5
- NFPA Fire Protection Handbook, current edition, chapter on 'Chemistry and Physics of Fire'

- Video

- NFPA Countdown to Disaster

- **Recommended Testing:**

Successful completion of a documented written or oral exam. (For example questions, see California Criminalistics Institute test questions).

2. Chemical composition of petroleum products.

- **Knowledge:**
Hydrocarbons, historical review of petroleum products, carbon numbers, homologous series.
- **Skills and Abilities:** N/A
- **Example Resources:**
 - Literature
 - Organic Chemistry, Morrison & Boyd
 - Chemistry and Life: An Introduction to General, Organic, and Biological Chemistry, John Hill, Stuart Baum, and Rhonda J. Scott-Ennis
 - Videos
 - Black Gold: The Story of Oil (part of the Empires of American Industry Series)
- **Recommended Testing:**
Successful completion of a documented written or oral exam.

3. Refinery Processes

- **Knowledge:**
Distillation, fractionation, cracking, alkylation, reformation, blending, seasonal and regional variations, marketing and distribution, product trends (isopars, norpars, naphthenics).
- **Skills and Abilities:** N/A
- **Example Resources:**
 - Literature:
 - The Implications of Refining Operations to the Characterization and Analysis of Arson Accelerants, Thornton & Fukayama,
 - Petroleum Refining, James H. Gary, Glen E Handwerk
 - Chemistry of Catalytic Processes, Bruce Gates, James Katzer, G.C.A. Schuit
 - The Chemistry and Technology of Petroleum (Chemical Industries, Vol 76), James G. Speight
 - Chromatography in Petroleum Analysis, K. Altgelt

- “Petroleum (Refinery Process, Survey), and Petroleum Products”, from Encyclopedia of Chemical Technology, Kirk & Othmer)
 - Petroleum: Its Composition, Analysis and Processing, Richard King
- Refinery tour
 - Manufacturer product information
- **Recommended Testing:**
Successful completion of a documented written or oral exam.

4. Effects of Fire

- **Knowledge:**
Effects of pyrolysis, evaporation, weathering, and combustion on petroleum products.
- **Skills and Abilities:**
Recognition of petroleum product at various stages of evaporation, weathering, and combustion.
- **Example Resources:**
Burn and evaporate petroleum products with periodic analysis by GC to observe changes over a range of fresh to depleted product. Burn various substrates and evaluate chromatograms.
- **Recommended Testing:**
Successful evaluation, prior to independent casework, of a series of unknown samples (suggested minimum number of 30) with 100% correct identification.

5. Health and Safety Risks: Chemical, Biological and Physical.

- **Knowledge:**
Bloodborne pathogens, hazardous materials right- to-know documents, compressed gas cylinder safety, flammability of solvents, explosive hazards, fire extinguisher information, proper disposal (biohazards, toxics, flammables, explosives), and general first aid protocol.
- **Skills and Abilities:**
Ability to properly label, store and dispose of a chemical. Awareness, recognition, and appropriate response to hazards in the workplace.

- **Example Resources:**

- Literature:

- North American Emergency Response Guidebook (USDOT) Guides 127-132 flammable liquids
- NFPA #704 Standard System for the Identification of Fire Hazardous Materials
- ASTM 752 Safety and Health Requirements Relating to Occupational Exposure to Carbon Disulfide
- Prudent Practices for Handling Hazardous Chemicals in Laboratories--National Research Council.
- Prudent Practices for Disposal of Chemicals from Laboratories--National Research Council.

- Internet references:

Oklahoma S.U., Safety training modules <http://www.pp.okstate.edu/ehs/modules;>

- Courses:

Hazmat and Hazwoper courses

- **Recommended Testing:**

Successful completion of a documented written or oral exam.

(For example, tests are included in each Ok.SU subject module.)

6. Investigative Process (Origin and Cause)

- **Knowledge:**

Understanding of the process of scene examination for the purpose of determining the origin and cause, significance of post fire indicators, fire pattern analysis, canine use and electronic sniffers. Recognition of building and furnishing materials and basic construction methods.

- **Skills and Abilities:**

Recognition of significance of fire patterns.

- **Example Resources:**

- Literature:

- Kirk's Fire Investigation, chapter 7
- US National Fire Academy "Fire and Arson Investigation"
- NFPA 921 current version

- Practical:

- Accompanying qualified fire investigators in field investigations
- Observe field use of canines and electronic sniffers.

- Collect and burn at least 10 different building and furnishing materials.
- Courses: NFA Fire and Arson Investigation
- **Recommended Testing:**
Successful completion of a documented written or oral exam.

7. Incendiary Devices

- **Knowledge:**
Recognition of components, residues and function of common improvised incendiary devices (fuels, firing train, residues, timing delays, Molotov cocktail, candles, match books). Potential value of trace evidence, fingerprints, associative evidence, physical matches and biological materials.
- **Skills and Abilities:**
Building simple incendiary devices. Use of stereo microscope. Manipulation of small amounts of material and small objects.
- **Example Resources:**
 - Literature:
 - US Army field manual on incendiary devices
 - Underground publications including internet sources.
- **Recommended Testing:**
Successful completion of a documented written or oral exam.
(For example, diagram the firing train of at least five improvised incendiary devices.)

8. Evidence Collection, Documentation and Packaging, Preservation and Chain of Custody.

- **Knowledge:**
Necessity for proper documentation, knowledge of available container and appropriate use and limitations. Proper sealing and labeling techniques. Sources and prevention of contamination. Relevance, appropriate quantity of submitted evidence and maintaining chain of custody.
- **Skills and Abilities:**
Ability to select appropriate containers, and recover evidence, seal and label properly with minimum damage and without contamination.
- **Example Resources:**

- Literature:
 - NFPA 921 chapter 9
 - Kirk's Fire Investigation, chapter 14
 - Various laboratory handbooks

- **Recommended Testing:**

Practical demonstration using various types of containers, in a variety of situations.

9. Other Evidence

- **Knowledge:**

General awareness of other aspects of forensic science (such as trace evidence, serological evidence, fingerprint evidence, drug evidence, toxicological evidence) and how they may interact with the role of fire debris analyst

- **Skills and Abilities:**

Ability to recognize, preserve, collect other types of evidence which may be associated with a fire, whether at a fire scene or received into laboratory. Familiarity with resources which can assist in proper handling. Ability to prioritize analysis and optimize the evidentiary value of items shared between laboratory sections.

- **Example Resources:**

- Literature:

- Forensic Science Handbook, R. Saferstein
- Criminalistics-An Introduction to Forensic Science, R. Saferstein
- Techniques of Crime Scene Investigation, B. Fisher
- Forensic Science--An Introduction to Criminalistics, P. DeForest, R.E. Gaensslen, and H. Lee

- **Practical:** Visit other forensic laboratory sections to observe and discuss evidence

- **Recommended Testing:**

Practical demonstration of collection and preservation techniques. Successful completion of a documented written or oral exam.

10. Recovery and Separation of Ignitable Liquids

- **Knowledge:**

Familiarity with all separation techniques (steam distillation, solvent extraction, dynamic adsorption elution, passive adsorption elution, heated headspace, SPME). Advantages and limitations of each technique.

- **Skills and Abilities:**

Determine and perform the appropriate extraction procedure best suited for a given fire debris sample.

- **Example Resources:**

- Literature

ASTM standard practices:

- E1386 Standard Practice for Separation and Concentration of Ignitable Liquid Residues from Fire Debris Samples by Solvent Extraction
- E1388 Standard Practice for Sampling of Headspace Vapors from Fire Debris Samples
- E1412 Standard Practice for Separation and Concentration of Ignitable Liquid Residues from Fire Debris Samples by Passive Headspace Concentration
- E1413 Standard Practice for Separation and Concentration of Ignitable Liquid Residues from Fire Debris Samples by Dynamic Headspace Concentration
- D6520 Standard Practice for the Solid Phase Micro Extraction (SMPE) of Water and its Headspace for the Analysis of Volatile and Semi-Volatile Organic Compounds
- Gas Chromatography in Forensic Science (Ellis Horwood Series in Forensic Science), I. Tebbett (Editor)

- Practical

- Demonstration of recovery techniques as available in laboratory.

Recommended Testing:

Perform different extraction techniques on similar samples; compare and evaluate results by gas chromatography.

11. Theory of Gas Chromatography

- **Knowledge:**

Gas chromatography theory. Types of columns (Advantages and limitations). Different carrier gas choices. Temperature programming. Detector selection.

- **Skills and Abilities:**

Ability to select appropriate column, instrument parameters and detector.

- **Example Resources:**

- Literature:

- Basic Gas Chromatography (Techniques in Analytical Chemistry), McNair & Miller
- Analytical Gas Chromatography, Jennings
- Modern Practice of Gas Chromatography, Grob
- High Resolution Gas Chromatography, Hyver & Sandra (HP)
- Gas Chromatography in Forensic Science (Ellis Horwood Series in Forensic Science), I. Tebbett (Editor)
- ASTM E355 Standard Procedure for Gas Chromatography Terms and Relationships

- Courses:
 - Chroma-Skills, Inc. courses.
 - Instrument manufacturer's courses
 - McNair course in gas chromatography (ACS)

- **Recommended Testing:**

Successful completion of a documented written or oral exam.

12. Practical Gas Chromatography

- **Knowledge:**

Column installation, leak detection, maintenance, general trouble shooting, injection techniques, calibration, contamination issues, and quality assurance.

- **Skills and Abilities:**

Ability to operate and perform routine maintenance of gas chromatograph and obtain reproducible data.

- **Example Resources:**

- Literature:

- Manufacturer's manuals
- ASTM E1510 Standard Practice for Installing Fused Silica Open Tubular Capillary Columns in Gas Chromatographs
- ASTM E594 Standard Practice for Testing Flame Ionization Detectors Used In Gas or Supercritical Chromatography

- Courses:

- Chroma-Skills, Inc. courses.
- Instrument manufacturer's courses
- McNair course in gas chromatography (ACS)

- Practical:

Operation of available instrumentation.

- **Recommended Testing:**

Practical demonstration of skill by running an appropriate number of samples (suggested minimum number of 30) and obtaining reproducible and accurate data as compared with known standards.

13. Gas Chromatography/ Mass Spectrometry

- **Knowledge:**

Theory, practice and maintenance of mass spectrometry and selected ion methods.

- **Skills and Abilities:**
Successful operation and routine maintenance of the mass spectrometer and extracted ion profiling for fire debris samples.
- **Example Resources:**
 - Literature:
 - Introduction to Mass Spectrometry, Watson
 - Interpretation of Mass Spectra, McLafferty and Turececk
 - Forensic Mass Spectrometry, edited by Yinon, Chapter 5 “Arson Analysis by Mass Spectrometry”, Martin Smith.
 - Manufacturer’s manuals
 - ASTM E1618 Standard Guide for Identification of Ignitable Liquid Residues in Extracts from Fire Debris Samples by Gas Chromatography-Mass Spectrometry
 - Courses:
 - Chroma-Skills, Inc. courses.
 - Instrument manufacturer’s courses
 - McNair course in gas chromatography (ACS)
 - Practical:
 - Operation of gas chromatograph/mass spectrometer
- **Recommended Testing:**
Practical demonstration of skill by running an appropriate number of samples (suggested minimum number of 30) and obtaining reproducible and accurate data as compared with known standards.

14. Classification, Interpretation and Identification

- **Knowledge:**
Recognition of gas chromatographic and mass spectral data of ignitable liquids and pyrolysis products and other interfering matrices. Classification of ignitable liquids as described in ASTM 1387 and 1618.
- **Skills and Abilities:**
Interpret and identify ignitable liquids using peak pattern recognition techniques. Ability to recognize GC and GC/MS patterns of common pyrolysis products and other interfering matrices. Classification of unknowns
- **Example Resources:**
 - Reviewing in-house reference standards
 - Literature:

- Annual Book of ASTM Standards, General Methods and Instrumentation, Volume 14.02 Forensic Sciences ASTM E1387, E1618.
- **Recommended Testing:**
Successful classification, prior to independent casework, of a series of unknown samples (suggested minimum number of 30) with 100% correct identification.

15. Report Writing

- **Knowledge:**
Basic writing technique to accurately document analysis and convey results of scientific data and opinions. Good command of in-house laboratory protocol.
- **Skills and Abilities:**
Ability to accurately record observations, testing procedures and results. Ability to write a clear, truthful, unbiased and concise laboratory report reflecting findings, results and interpretation of data.
- **Example Resources:**
 - Literature:
 - Guidelines of in-house laboratory exemplar reports
 - ASTM E-1618
 - E-1387, section on report writing.
 - Harbrace College Handbook, John Hodges and Mary Whitten
 - Writing Research Papers, James Lester
 - Writers INC, a Guide to Writing, Thinking, and Learning, Patrick Sebranek, Verne Meyer, Dave Kemper
 - The Elements of Style, E.B. White and William Strunk, Jr.
- **Recommended Testing:**
Successful writing of reports encompassing the potential range of analytical results.

16. Courtroom Testimony and Presentation Techniques

- **Knowledge:**
Legal system including terminology, courtroom proceedings and deposition. Roles of expert witnesses. Presentation techniques using various media including computer, transparencies, slides, charts, video and graphs, etc.

- **Skills and Abilities:**

Ability to research, organize and communicate results and conclusions, succinctly in a simple manner understandable to lay person. Maintaining a professional demeanor and appearance. Unbiased presentation of scientific data.

- **Example Resources:**

- Literature:

- *Frye vs United States*
- *Daubert vs Merrell Dow Pharmaceuticals*
- *Kumho vs Carmichael*
- Federal Rules of Evidence, #702
- *Michigan vs Tyler*
- *Michigan vs Clifford*
- Is Daubert Limited to Scientific Testimony, W. J. Andrews, B. A. Hawthorne
- On Being a Good Expert Witness in a Criminal Case, J. Kogan
- Computer books, programs and manufacturers instruction.

- Audiovisual training tools
Ethics and Arson Investigation

- Courses

- CCI courtroom testimony course
- IAAI courtroom testimony course

- Practical

Attend courtroom during one whole trial and on several occasions with an experienced expert witness from laboratory.

- **Recommended Testing:**

At least one mock trial including various media presentation formats.

17. Quality Assurance/Validation Methodology

- **Knowledge:**

Understanding of the importance of quality assurance/quality controls to assure integrity of laboratory process at every level. This includes validation of method protocols prior to use, as well as quality assurance of case analysis routinely documented.

Knowledge of blanks, reagent controls, glassware cleanliness, mechanisms to recognize, avoid, or correct contamination within instrument, samples, reagents & solvents, instrument maintenance logs, etc.

- **Skills and Abilities:**

Ability to articulate and apply appropriate checks within a method during analysis to determine whether contamination could be detected if it occurred. Documentation of instrument parameters, maintenance performed, blank and reagents within a run, reagent purity validation, etc.

- **Example Resources:**

- Literature

- Various laboratory procedure and protocol manuals (e.g. ASCLD/LAB Quality Manual)
- Instrument manuals

- **Recommended Testing:**

Review of chemists' work product and maintenance logs. Participation in proficiency tests, with 100% correct score prior to conducting independent casework. In the event of an error in identification, documented remedial training is required.