SAN DIEGO POLICE DEPARTMENT
CRIME LABORATORY
TRACE EVIDENCE UNIT MANUAL

Trace Unit Manual

Approved By: Alyson Talbot, Supervising Criminalist

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1.1 UNIT OVERVIEW

UNIT DESCRIPTION

The Trace Evidence Unit is located on the 6th floor of the San Diego Police Department Headquarters building. The general hours of operation are Monday through Friday, 0600 hours until 1630 hours.

The unit is composed of one Supervising Criminalist, one Criminalist III technical lead, and a staff of Criminalists.

The unit adheres to the requirements of the Laboratory Quality Assurance Manual. Additional requirements specific to the Trace Evidence unit are listed in this manual.

UNIT FUNCTIONS

The criminalists in the Trace Evidence Unit perform several different types of analyses. These include analyses in the following areas:

- General Analysis
- Fire Debris and Ignitable Liquids
- Fiber
- Hair
- Impression
- Explosive
- Paint
- Physical Match
- Gunshot Residue

Additional duties may include:

- Crime Scene Reconstruction
- Projects assigned by the unit Supervising Criminalist

FACILITY

The Trace Evidence unit is comprised of the main unit, an instrument room, and an SEM room. The unit doors will remain closed and locked during business hours. The unit is considered a secure evidence storage room.

EVIDENCE HANDLING

Unit personnel will maintain control of their evidence by ensuring that case evidence is not in an area where the evidence can be lost, compromised, or altered. They will wrap or cover the evidence, as needed, to ensure evidence integrity.

The analyst must ensure that tools, examination area, laboratory coat, and gloves are clean. Each item of evidence is examined on a clean surface. Based on the types of analyses, the clean surface can be new butcher paper, clean glassware, or clean counters. Bleach is not stocked or used in the unit for cleaning due to its property of changing dye coloration of fibers and hairs. For evidence that may go to DNA testing, counters are wiped multiple times with alcohol prior to examination, and new butcher paper and new gloves are used during the screening examination of each item.

The examination of questioned and known reference items of evidence are separated either by location or by the examination of items at different times.

Victim and suspect evidence will be examined in an effective manner to prevent any contamination.

To prevent GSR contamination of the work areas within the unit, situations where contamination might occur and the appropriate precautions to take are outlined below:

- An analyst is exposed to primer residue during a firearms examination.
    - The analyst will not examine firearms in the Trace Evidence unit.
    - A separation in time and location is desired for firearms examination by trace examiners.
    - The area to be used for the firearms exam will be cleaned before and after any firearms examination and a single use lab coat will be worn.
- Test firing
    - The analyst will wear a single use lab coat. This will either be a disposable lab coat, or the lab coat will be washed after one use.
    - The analyst will wash his hands and face after test firing or contact with firearms.
    - The analyst will not perform any GSR/SEM analysis on the same day that he or she test fires or has contact with a firearm.
- Firearm qualifications/shooting range practice
    - The analyst will schedule range qualification and practices in the afternoon and avoid the trace evidence area after qualifications or range practice.

2.1 GENERAL ANALYSIS

Materials and Equipment

Reagents and Supplies

- Permount
- Xylene
- Refractive index liquids
- Glass slides
- Coverslips
- Forceps
- KBr
- NaCl plates
- Standard Materials
- Sample mounting stubs for SEM
- Methanol for GCMS
- Carbon Disulfide

Equipment

- Stereomicroscope
- Polarizing microscope
- FTIR microscope
- Scanning electron microscope with EDS
- FID-GC
- GC/MS

Procedures

General Guidelines

- Items submitted for general analysis include a wide variety of materials. The Supervising Criminalist shall assign a Criminalist to each case based on the type of examination requested and the instrumentation and expertise required to perform the analysis.

Evidence Handling

- Preliminary Considerations
  - Prior to the analysis of evidentiary material, an evaluation of the relevant elements of each case should be obtained through communication with the submitting detective and/or prosecutor. This evaluation should include an assessment of the evidence and its relevance.
- Special Considerations
  - Trace evidence can be contaminated during laboratoryexamination.
  - The analyst must ensure that tools, examination area, laboratory coat, and gloves are clean.
  - Examine each item of evidence on a clean piece of butcher paper.
  - Separate the examination of questioned and known reference itemseither by location or by examination of the items at different times.

Goals of Examination

Identification: Liquid, powder, or granular material can be examined utilizing a variety of instrumental, microscopic, and microchemical techniques. A variety of evidence could fall under the category of general unknowns (e.g. caustics, bleach, tear gas, glass, plastics, wax, organic compounds, metals, wood, chalk, diatomaceous earth, fire extinguishers, match heads, safe insulation, etc.).

Physical Matches and Comparisons: A variety of materials can be examined for physical characteristics to determine if two items could share a common source or can be physically matched back to the original source. Examples of physical matching can include fractures in metal, wood, plastics, tears in tape, paper, fabric, etc. When a physical match is not possible, then the questioned and known samples can be physically and chemically characterized to determine if they share a common source.

General Approach

The analyst will evaluate the exhibit and attempt to characterize the type or class of evidence. The analyst can choose microscopic, microchemical, or instrumental methods of examination. Appropriate controls, standards and laboratory procedures will be employed. Appropriate safety precautions will be exercised on unknown exhibits. The analyst will consider the possibility of toxic substances or reactions. For example, cyanide or tear gas exhibits would require personal protective gear and/or analysis in the hood. The analyst will evaluate the type of evidence, the amount of evidence, and the potential for interpretation in making the decision to use specific types of instrumentation. In most cases, destructive testing such as pyrolysis or solubility is to be avoided. See the general policy for evidence consumption.

The analyst will also be aware of other types of evidence such as fingerprints, blood, semen, and narcotics. The analyst will safeguard the evidence by sequencing the types of examinations to minimize any loss of evidence through sampling. The potential for individualizing must be considered paramount. If fingerprints or DNA evidence could be compromised, the analyst will consult with the appropriate sections to determine the sequence of examinations.

Standards of Performance

Focus: The aim of this type of analysis is to identify an item chemically and/or physically to the exclusion of all other classes of items or to determine if two items are similar and could have come from the same source. The analyst will evaluate the evidence and decide the best analytical approach. The type and amount of evidence will dictate the analytical approach. Each case will be evaluated on its own merits. It is recognized that no single analytical approach can cover all types of examinations. This is only meant to provide a guide or framework.

The analyst will document the condition of the evidence as received, the date the evidence was received, and will provide a written description of the items received. The analytical notes will reflect the examinations conducted and the results and/or conclusions reached and will include appropriate sketches, photographs, and analytical printouts. The notes should enable the technical reviewer to reconstruct the analytical steps taken and compare any spectra or data.

Infrared examination with high quality spectra and standards is a conclusive identification. GCMS with high quality spectra and standards also constitutes an identification. Polarized light microscopy with microchemical or other confirmatory tests can be a conclusive identification. An energy dispersive spectrum on the SEM can qualitatively describe the elemental composition of a sample. It is highly desirable to have two independent forms of examination applied to a sample for an analytical conclusion.

If the evidence falls under a method described elsewhere, those standards (under that method) will be applied.

Methods of analysis will be validated and scientifically justified. The methods will be reproducible. Another analyst should be able to derive the same information from the same evidence or data. The analyst will avoid consuming all of the evidence. Some of the evidence must be maintained for defense analysis.

Opinions and Interpretations

If an item has been identified chemically and/or physically the analyst can report precisely that a particular compound was found in the submitted item. The analyst needs to be specific in explaining why certain examinations were conducted and the significance of these examinations. Not detecting a substance can mean that the levels present are below the sensitivity of the method or that the substance is not present.

When a physical match has been demonstrated, the analyst can state that the two pieces (items) were at one time, one piece. (See section 2.8 Physical Match Analysis).

References

Walter C. McCrone, Lucy B. McCrone, and John G. Delly, "Polarized Light Microscopy", Michigan: Ann Arbor Science Publishers, 1978.

Frederick Cunliffe and Peter Piazza, "Criminalistics and Scientific Investigation", New Jersey: Prentice-Hall Inc., 1980.

Operation manuals for the GC, GCMS, FTIR, FTIR microscope, and the SEM.

2.2 FIRE DEBRIS ANALYSIS

MATERIALS AND EQUIPMENT

Reagents and Supplies

- CS_2 (Use this material in a hood, with proper personal protection equipment)
- Activated charcoal strips
- Injection syringes - gas and liquid
- Dental floss
- Paper clips
- Magnets
- Cotton swabs
- Forceps
- Glass sample vials with Teflon septa
- Standard accelerants
- Resolution test mixture (Restek)
- Glass wool/cotton
- Other reagents as needed e.g. Pentane, chloroform, etc.
- Glass Pasteur pipettes

Equipment

- GC-FID
- GC/MS
- Oven (up to 100 ^{o} C)

PROCEDURES

Evidence Handling/Documentation

- Preliminary Considerations
    - Solid debris: Solid debris evidence suspected of containing a flammable liquid is collected at the scene in 1 gallon or smaller paint cans with crimp type lids firmly sealed. These cans are preferably epoxy coated and should be tested on a lot-by-lot basis for the presence of petroleum products prior to being used for evidence collection. The laboratory tests every lot submitted by the investigators. The laboratory does not provide these cans to the investigators. Other suitable material for larger items is Kapak. This material is available in pre-made bags, or in rolls for very large items. Each lot of the Kapak material should be tested prior to use.
    - Comparison samples: The investigator should submit comparison samples with each case. These may include unburned and uncontaminated carpeting, padding, upholstery padding, wood, etc. The comparison samples are analyzed using the same procedures as those utilized for analysis of the unknown samples.

- Liquid evidence: Liquid evidence is collected from the scene and placed in a tightly capped glass vial. If liquid is found in its original container, collect the container.

- Documentation
  - The form in which the evidence is received should be described, and the integrity of the container noted. If solid debris is submitted in a paint can, the can should be opened carefully. Quickly make note of the contents and any odors, then reseal tightly. If a liquid sample is submitted, make note of the color, the presence of layers, and any odors. Notes can also be taken on clarity, viscosity, or other notable conditions. For safety reasons, do not purposefully smell or inhale the odors from an evidence container.
- Sample Extracts
  - All extracts created during analysis will be considered a work product of the Trace Unit.

Sample Preparation

- Passive adsorption/elution - solid sample
  1. Suspend a carbon strip in the interior of the can or Kapak bag. The carbon strip should not come into direct contact with any of the contents if possible. Contact with materials can overload the strip. This can be avoided by splitting up the sample between two containers. If the strip does come in prolonged contact with the material in the can or Kapak bag, keep this in mind when evaluating the chromatogram for apparent overloading of the strip.
  2. Reseal the cans tightly or seal the Kapak bags with tape. Heat the sample and blank charcoal for 1 - 2 hours at 80^{o}C or leave cans or Kapak bags at room temperature overnight. If a Class 4 or 5 accelerant is indicated after room temperature adsorption period, insert a new carbon strip, and repeat the procedure heating for 1-2 hours at 80^{o} C.
  3. Remove strips and place in small glass vial with 20 - 50 drops of CS2. Cap tightly.
  4. Prepare CS2 blank to be analyzed with each set of samples.
- Liquid Extraction - liquid sample
  1. Test flammability (if the volume permits, per analyst discretion).
     - Suggested method for testing flammability:
       - Moisten a cotton swab with the liquid
       - Place the swab in a flame
       - Document and observe reaction (flammable or not flammable)
  2. If necessary, filter liquid through Pasteur pipette containing glass wool to remove particulates.
  3. Dilute sample appropriately with CS2.
  4. Prepare CS2 blank to be analyzed with each set of samples.
- Liquid Extraction – Solid Sample (This procedure is a destructive procedure and should only be utilized when other extraction methods have failed to yield results.
  1. Transfer a representative portion of the sample to suitable container (beaker, test tube, Kapak bag, etc.) of the appropriate size.

2. Add enough solvent (CS_2, pentane, etc.) to just cover the material.
3. Agitate by stirring, shaking, or vortexing for a few minutes.
4. Decant or pipet off solvent. Filter the solvent if particulates are present using filter paper, a Pasteur pipet with glass wool or cotton, or other suitable filter apparatus into a smaller beaker.
5. Evaporate the extract down to a suitable volume using an air stream without heat.
6. Transfer the extract to an appropriately labeled autosampler vial.
7. Follow procedure for liquid analysis.
8. Prepare a blank of the solvent used for extraction (CS_2, pentane, etc.).

Instrumental Analysis (GC-FID and/or GC/MS)

- Prepared samples will be analyzed with GC-FID and/or GC/MS. The instruments used will be determined at the analyst's discretion.
- Analyze samples using the following steps (for any of the instruments):
  1. Blank - Inject 1µl CS_2 (or solvent used) prior to sample analysis and between samples
  2. Standard- Resolution test mixture (Restek), inject 1µl or less
  3. Samples - Inject 1µl or less of sample
  4. References - run fresh standard accelerants (from library) under the same conditions as the sample (if required). Inject 1ul or less

- A commercially available resolution test mixture (Restek) that includes n- alkanes will be run every time there is significant maintenance on the instrument that could alter retention times, and after the yearly preventative maintenance service.
- Note: Should evidence be suspected of containing light volatiles (e.g. chemical odor or flammable liquid), but no identifiable ignitable liquid residues are present, the GC/MS method will be switched to the lights detection method.

Interpretation

- The classification system is based on the ASTM guideline E1618-19 and is describe in Table 1.
- It may be necessary to characterize a product as light to medium or medium to heavy when the carbon range doesn't neatly fit into one of the categories. In such instances, the carbon number range should be reported.

TABLE 1

Class 1: Light Petroleum Distillates

Majority of the pattern occurs in the C_4 to C_9 range of normal alkanes. No major peaks above C_{11}.

Class 2: Gasolines

Pattern characterized by abundant aromatics in a specific pattern. Petroleum pattern comparable to reference ignitable liquids; m-ethyltoluene, p-ethylbenzene, 1,3,5-trimethylbenze, o-ethyltoluene, and 1,2,4-trimethylbenzene shall be present above C_7. The aromatic concentration is substantially higher than the alkane concentration. Naphthaleneand indanes could be absent in some gasolines. The mere presence of alkylbenzenes does notjustify an identification, but the compounds shall be present in the sample at the same relative concentrations as observed in samples of known gasolines.

Class 3: Medium Petroleum Distillates (MPD)

Peaks present in the alkane range of C8 to C13. No major peaks associated with ignitable liquid below C7 or above C14.

Class 4: Kerosenes/Medium to Heavy Petroleum Distillates

Peaks present in the range of C9 to C16. At least five consecutive n-alkane peaks between C12 and C17 must be present.

Class 5: Heavy Petroleum Distillates (HPD)

Peaks in the alkane range C9 to C20+. Pattern starts above C9 and at least five consecutive n-alkane peaks must be present.

Class 0: Miscellaneous

Variable peak spread. One to several peaks present consisting of ignitable liquid components, such as alcohols, aromatics, and/or alkanes. For best classification a known comparison sample should be submitted.

Note Packet

- Include how samples were extracted for analysis.
- When a sample chromatogram displays all the features that the analyst feels necessary for a particular class identification, the report will state that a petroleum product of that class was detected. It will also name examples of the class, except in the case of a class 2 (gasoline). Gasoline is sufficiently characteristic that it can be reported as a single item rather than as a class.
- Include in final notes the chromatograms of all standards, samples, and blanks produced during the analysis.
- Document the lot number of reagents and/or supplies within the case packet, as needed.
-

Opinions and Interpretations

- Suggested wording:
  - Identification (solid debris) - A class ( ) petroleum distillate was detected. Alternately, the terms Light, Medium, Heavy (LPD, MPD, HPD) may be used instead of the class. Examples of these include, but are not limited to:
  - Identification (liquid) - The liquid was identified as a class ( ) petroleum distillate. Examples of these include, but are not limited to:
  - Non-Identification - No identifiable ignitable liquids were detected. Instances of non-identification could include: analyst did not find evidence of an

accelerant, analyst was unable to identify accelerant, or analyst was unable to exclude pyrolysis products or substrate as source of accelerant.

References

Richard Saferstein, "Forensic Science Handbook", New Jersey: Prentice Hall Regents, 1982.

John O'Conner, "Practical Fire and Arson Investigation", New York: Elsevier Science Publishing Company Inc., 1987.

John DeHaan, "Kirk's Fire Investigation", New Jersey: Prentice-Hall Inc., 1991.

2.3 FIBER ANALYSIS

MATERIALS AND EQUIPMENT

Reagents and Supplies

- Permount
- Xylene
- Refractive index liquids
- Glass slides
- Cover glass
- Forceps
- Tape lifts
- Razor blades
- BaF_2 cells
- Micro sample press
- Pipette tips
- Acrylic yarn (white and blue)
- Chloroform
- Methanol
- Acetic Acid
- Pyridine
- Diamond compression cell
- Collodion

Equipment

- Stereomicroscope
- Polarized light microscope
- FTIR microscope
- Comparison microscope
- Hot glue gun
- Hardy microtome
- Hardy thin cross-sectioning device
- UV light box
- ALS
- Mettler hot stage

PROCEDURES

Evidence Handling

Preliminary Considerations

- Trace evidence examinations can employ chemicals and reagents that are known carcinogens and/or hazardous substances. Therefore, the examiner should read the guidelines published by NIOSH and the Material Safety Data Sheets for all reagents and chemicals that are used.

Special Considerations

- Trace evidence can be contaminated during laboratory examination.
- The analyst must ensure that tools, examination area, laboratory coat, and gloves are clean.
- Examine each item of evidence on a clean piece of butcher paper.
- Separate the examination of questioned and known reference items either by location or by examination of the items at different times.
- The questioned items will be examined first and documented before the known items are examined.

Collection of Fiber Evidence

- Collection of questioned fibers – Items examined for fiber evidence are generally viewed visually for any apparent or significant fibers. These are documented, removed, and packaged separately. The following are appropriate collection techniques.
  1. Forceps – Fibers of interest may be located through a visual examination. If the fibers are large enough, collect the fibers with forceps and place in a paper bindle or on a tape lift for storage.
  2. Tape lifts – If the fibers are small, tape lifting is the recommended method for fiber recovery. A tape lift can be patted over the surfaces of the clothes to collect the fibers. The tape lift can then be used for storage of the fibers and for future examinations of the fibers.
  3. Alternate techniques
     a. Viewing with oblique lighting or with an ALS may enable the examiner to better visualize the fibers prior to collection.
     b. Scraping to collect fibers and debris from very dirty items where a tape lift would not be effective.

- Collection of standards/known samples - It is important when collecting a fiber sample to obtain an appropriate sample. Ensure that all shades and types of fibers from your sample are represented.
- Evidence storage and disposition - The fibers should be stored in paper bindles or on tape lifts. Evidence should be packaged to prevent cross-contamination.

Fiber Analysis

- Use non-destructive techniques first for both fiber identifications and comparisons. Evaluate any destructive testing for its potential value prior to proceeding. Record with sketches or photography the location of the fibers when this has special significance.
- Macroscopic analysis - Fibers are examined macroscopically for characteristics such as color, length, contour, thickness, and adhering debris. If fabric is submitted, characteristics such as weave pattern are noted. This examination is done with the fibers in an unmounted condition using low power magnification. The analyst may be able to differentiate between known and questioned fibers at this point, however further analyses must be done to identify fiber type.
- Microscopic analysis - Mount the fibers in an appropriate mounting media. Xylene can be used for a temporary mount and Permount can be used for a more stable mount. Each slide must be properly labeled for identification with the barcode number and case number or item number and property tag, analyst's initials, date, or other unique identifier. This examination is done utilizing a polarized light microscope with a calibrated eyepiece micrometer. The levels of magnification range from 40x to 1000x. Examine the fibers for the following properties:
    - Physical properties
        - Color
        - Diameter: approximate range in µm with an eyepiecemicrometer. Also note the regularity of the diameter
        - Cross-section
        - Delusterants: Note as to type, size, and amount.
        - Voids, spherilite formation, or any other unusual inclusions should also be noted
        - Twisting, marks, nodes etc.
    - Optical properties
        - Refractive index: $n_{\parallel}$ and $n_{\perp}$ are determined using the Becke line technique. The fiber is immersed in a series of Cargille liquids of known refractive indices. Using uncrossed polars, $n_{\parallel}$ is measured with the fiber parallel to the polarizer's vibrational direction. $n_{\perp}$ is measured with the fiber perpendicular to the polarizer's vibrational direction. The Becke lines moves the media of higher refractive index when the object is moved away from the objective.
        - Birefringence: Can be determined with the use of a Michel-Levy chart or by measuring $n_{\parallel}$ and $n_{\perp}$.

$$n_{\parallel} - n_{\perp} = \frac{\text{R (retardation in nm)}}{\text{(diameter in mm x 1000)}} = \text{birefringence D}$$

- Sign of elongation: Orient fiber with its long axis parallel to the slow ray on the ¼ wavelength compensator plate. Under crossed polars, insert the compensator plate and observe the change in interference colors. If additive retardation occurs, the sign is positive. If subtractive retardation occurs, the sign is negative. Alternately, determine the refractive indices in the two vibrational directions. If $n_{\parallel} > n^{\perp}$ the fiber is positive, if $n_{\parallel} < n_{\perp}$ the fiber is negative.
- Extinction: Rotate the specimen 360° between crossed polars. Determine if the fiber has parallel extinction.
- Pleochroism: Rotate the specimen 90° and note any color change in the fiber.

At the conclusion of this examination, the analyst may be able to differentiate between the questioned and known fibers based upon the optical and physical properties. This examination will also enable the analyst to identify most common types of fibers. At this time, if the fibers appear similar, a side-by- side comparison of the physical properties of the known and questioned fibers is done using a comparison microscope. See Appendix B and C for relevant information regarding fiber identification. In addition, a fiber reference collection is available containing both natural and synthetic fibers. A set of mounted reference fiber slides from McCrone is available in the laboratory. A set of unmounted reference fibers purchased from McCrone is also available in the laboratory.

- Cross-sectioning (if required)
  - There are many techniques available for cross-sectioning. This analysis should not be performed on the questioned fiber(s) if destruction of the evidence is an issue. The following three techniques are utilized in this laboratory:
  - Hardy Microtome
    1. Place the fiber in a small bundle of acrylic yarn fibers of a contrasting color.
    2. Place yarn bundle and questioned fiber into the slot in the microtome, close microtome to anchor the fibers in place.
    3. Cut off the excess fibers protruding on either side of the microtome with an unused razor blade.
    4. Place the microtome onto the microscope with the light directed through the fiber bundle.
    5. The cross-section of the fiber can then be observed and photographed.
  - Hardy Thin Cross-sectioning Device
    1. To use this method, a strand of fibers at least 1mm in diameter is necessary.
    2. Separate the parts of the cross-sectioning device.
    3. Release the lock and turn the swiveled bracket to a position transverse to the frame.
    4. Insert the fibers into the slot.
    5. Insert plates and press together.
    6. Cut off the surplus fibers that project from each side of the device.
    7. The fibers should now be flush with the plate.

8. Swing the bracket back into position and lock with the taper pin.
9. Screw down micrometer screw until the fibers may be seen projecting slightly from the reverse side of the plate.
10. Coat these projecting fibers with a thin solution of collodion and allow fibers to dry.
11. Slice off dried film of collodion containing the fiber cross- sections and discard.
12. Turn the screw head according to the thickness of the cross-section desired (usually 1/3 of a single gradation on the top of the screw).
13. Apply a thin coating again to the exposed face of the fibers and allow to dry.
14. Slice off the dried film of collodion containing the cross- sections and mount on a microscope slide using an appropriate mounting media.
15. Place slide on microscope, observe and document cross- sections.

- Glue gun/pipette tip technique
  1. Place fiber in the open end of a pipette tip.
  2. Place a drop of hot glue into the opening, surrounding the fiber.
  3. Allow glue to dry and harden.
  4. Slice thin cross-sections of the fiber in the pipette tip with a sharp razor blade/scalpel blade.
  5. Mount cross-sections on a slide using an appropriate mounting media.
  6. Place slide on microscope, observe and document cross- sections.
- By hand
  1. Place fiber on slide and place another slide or cover slip on top.
  2. Move the fiber to allow a small area to be sticking out from the top slide
  3. Using preferred cutting tool, cut the fiber as thin as possible
  4. Mount the cross-sections on a slide using an appropriate mounting media.
  5. Place slide on microscope, observe and document cross-sections.

- FTIR microscope
  - The infrared analysis of the questioned fiber can enable the analyst to identify the type of fiber based upon the molecular structure. In addition, this technique will enable the analyst to compare the structure of the known and questioned fibers to each other. This technique is particularly useful when attempting to differentiate between to similarly colored fibers of the same class.
    1. Prepare sample by flattening as much as possible.
    2. Place the fiber between two diamond compression cells.
    3. Run the sample on the FTIR according the manufacturer's suggestions.
    4. Search library for best match.
  - Print all scans used in analysis and label appropriately for notes.

Opinions and Interpretations

- Comparison
  - Association - The questioned and known fibers could share a common source. Conditions - There are no significant differences in any of the macroscopic, microscopic, or chemical characteristics.
  - Elimination - The questioned and known fibers do not share a common source.
    Conditions- Questioned and known fibers exhibit significant differences in their macroscopic, microscopic, or chemical characteristics.
  - Inconclusive - The questioned and known fibers show both similarities and differences such that no clear conclusion can be drawn.
    Conditions - Analyst is unable to identify a fiber or do a meaningful or extensive comparison due to the small sample size, possible environmental decomposition, or other uncontrollable factors.
- Identification
  - Identification:
    Synthetics – fiber is identified as an acetate, acrylic, nylon, polyester, etc.
    Animal – fiber is identified as wool, angora, etc.
    Vegetable – fiber is identified as cotton, linen, etc.
    Mineral – fiber is identified as fiber glass, glass wool, etc.
  - Inconclusive - The analyst is unable to identify the fiber due to the small sample size, possible environmental decomposition, or other uncontrollable factors.
    - Note: When an identification of fiber type is made AND reported, the technical reviewer will examine the fiber to the degree necessary to determine the generic fiber type.

References

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OMNIC FTIR Software User's Guide, Version 3.0, Nicolet: 1996.

(***Appendices Follow)***

APPENDICES

Appendix A (see reference 1)

Refractive Indices of Fibers

Fiber	n‖	n⊥	*Birefringence*
ACETATE			
Diacetate	1.476	1.473	0.003
Triacetate	1.469	1.469	0
ACRYLIC			
Acrilan 36	1.511	1.514	-
Courtelle	1.511	1.514	-
Orlon 42	1.511	1.515	-
ARAMID			
Kevlar	>2.00		
ASBESTOS			
Chrysotile	1.50 - 1.56	-	varies
Amosite	1.64 - 1.69	-	varies
Crocidolite	1.68 - 1.71	-	varies
CHLOROFIBER			
Fibravyl	1.541	1.536	0.005
CUPRO			
Cuprammonium rayon	1.553	1.519	0.034
GLASS			
A-glass	1.542	-	-
E-glass	1.550	-	-
S-glass	1.523	-	-
C-glass	1.541	-	-
MODACRYLIC			

Dynell	1.535	1.533	0.002
Teklan	1.520	1.516	0.004
NYLON			
Nylon 11	1.553	1.507	0.046
Nylon 6	1.575	1.526	0.049
Nylon 6, 6	1.578	1.522	0.056
POLYESTER			
Terylene	1.706	1.546	0.160
POLYOLEFIN			
Polypropylene	1.530	1.496	0.034
Polyethylene	1.574	1.522	0.052
VISCOSE			
Normal tenacity viscose	1.542	1.520	0.022
High tenacity viscose	1.544	1.505	0.03
High wet modulus viscose	1.551	1.513	0.038
WOOL	**1.557**	**1.529**	**0.010**
COTTON	**1.577**	**1.529**	**0.04**
SILK			
Degummed	1.591	1.538	1.538
FLAX	1.58 - 1.60	1.52 - 1.53	0.06

Appendix B

Fiber Identification

Manmade: uniform continuous cross-section Natural:

shorter with discontinuities along length

Birefringence

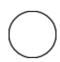
Low - <0.01

Medium - $0.01 - 0.05$

High - > 0.05

Isotropic Fibers

Glass Wool



Uniform diameter
Straight Colorless
n’s ~ 1.52

Mineral Wool
Exoticshapes
Irregular diameters
May be colorless, gray, or brown
n’s ~ 1.52 - 1.70

Triacetate (Arnel)

Not truly
isotropic n’s ~
1.469
BR - 0.0001

Anisotropic Fibers

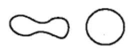
LOW

Acetate (+)

n∥ ~1.478
n⊥ ~1.473

Acrylics (-)

n∥ ~1.511
n⊥ ~ 1.515



Modacrylics

Dynel (+)
n's ~ 1.53

Scales
BR = 0.009

MEDIUM

Coniferous Wood
Flat fibers with 1 – 2 rows of pits

Non-Coniferous Wood
Flat cells, usually without pits; baggy cells with many rows of pits

Straw (Nylon)
Lignified, serrated cells, baggy cells

Jute
Rounded polygonal, nodes lumen varies in diameter
n ∥ ~1.58
n⊥ ~1.53

Cotton
Twists, no extinction n∥ ~1.58
n⊥ ~1.53

Olefins
Polyethylene
n∥ ~1.57
n ~1.52
Polypropylene n∥ ~1.53
n⊥ ~1.496

Viscose n∥
~1.55
n⊥
~1.52

Asbestos
Very fine fibers

Mineral

Crysotile
n∥ ~1.55
n⊠ ~1.54

Amosite:
n∥ ~1.69
n⊥ ~1.67

Crocidolite:
n∥ ~1.70
n⊥ ~1.71

HIGH

Rayon, Silk
Rounded trilobal cross-over marks
n∥ ~1.59
n⊥ ~1.54

Flax (linen)
Rounded polygonal nodes
n∥ ~1.59
n⊥ ~1.525

Ramie
Long coarse fibers, rounded cross-section nodes
n∥ ~1.60
n⊥ ~1.53

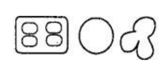
Hemp
Rounded polygonal, nodes
n∥ ~1.59
n⊥ ~1.53

Polyester
Any shape
n∥ ~1.71
n⊥ ~1.54

Polyamide (Nomex)
Cylindrical
n∥ ~1.75 - 1.80+
n⊥ ~1.67

Aramid
Cylindrical
n∥ ~2.35
n ~1.64

Polyamide
Any shape
n∥ ~1.58
n⊥ ~1.52



2.4 HAIR ANALYSIS

MATERIALS AND EQUIPMENT

Reagents and Supplies

- Permount
- Xylene
- Glass slides
- Coverslips
- Forceps

Equipment

- Stereomicroscope
- Polarized light microscope
- Comparison microscope
- Sonicator

PROCEDURES

Evidence Handling Preliminary

Considerations

- Prior to analysis of evidentiary material, an evaluation of the important elements of each case should be obtained through communication with the submitting investigator and/or prosecutors. This evaluation should include an assessment of the evidence and its relevance.
- Special Considerations
    - Trace evidence can be contaminated during laboratory examination.
    - The analyst must ensure that tools, examination area, laboratory coat, and gloves are clean.
    - Examine each item of evidence on a clean piece of butcher paper.
    - The questioned items must be examined prior to the known items.
    - Separate the examination of questioned and known reference items either by location or by examination of the items at different times.

Collection of Hair Evidence

- Collection of questioned hairs
  - Items examined for hair evidence are generally viewed visually for any apparent hairs. The following are appropriate collectiontechniques:
  - Forceps - Hairs may be located through a visual examination. If the hairs are large enough, collect them with forceps and place in a paper bindle or on a tape lift for storage.
  - Scraping – Items examined can be scaped using tools to collect questioned hairs remaining on the surface of the item. Any hairs observed through visual examination can be placed in a paper bindle or on a tape lift for storage.
  - Tape lifts - If the hairs are small or difficult to see, tape lifting is the recommended method for recovery. A tape lift can be patted over the surfaces of the clothes to collect the hairs. The hairs may be collected from the tape lift for examination at a later time.
- Collection of hair standards
  - Head: A known head hair sample consists of at least 25 hairs, preferable 100 hairs, from each of five different areas of the scalp (front, center, back, and both sides). The hairs will be obtained by pulling and finger combing.
  - Pubic: A known pubic hair sample consists of at least 20 hairs from all different areas of the pubic region. The hairs will be obtained by pulling and finger combing.
  - For collection of hair standards of deceased individuals at the autopsy, the hairs can be collected after the body has been washed.
  - Guidelines: these requirements are subject to the condition of the subject's hair. In some cases, it may not be necessary or even possible to collect the suggested number of hairs. It also may be necessary to collect the hairs before the body is washed. Each situation will dictate whether trace evidence that might be present in the head hair is significant or not. Laboratory personnel can use their discretion as appropriate.
- Evidence Storage and Disposition
  - Evidence should be packaged to prevent cross contamination. If a hair is determined to be suitable for DNA analysis, store the hair in the freezer. If no DNA testing appears warranted, paper bindles placed in coin envelopes at room temperature is the preferred method for long-term storage.
- Macroscopic ExaminationExamine the questioned hair macroscopically using low power magnification. Thefollowing characteristics should be noted if appropriate:
  - animal or human origin
  - condition of tip and root
  - length
  - somatic origin
  - disease
  - color
  - chemical alterations
  - contour
  - debris
  - cross-section
  - It is important to note the presence of any cells on the root in order to

determine suitability of hair for nuclear DNA analysis.

- A similar examination is performed on the hair standards. At this point in the analysis, the analyst makes a determination on similarity between the questioned hair and the hair standards. In order to conclude a questioned hair is similar to a known hair standard, there must be no significant differences in the characteristics outlined above. If the questioned hair is similar to the hair standard and has a root with visible cellular material, the hair is reported as similar tothe hair standard and recommended suitable for DNA analysis. If the questioned hair is not similar to the standard hair, the hair is reported as not similar to the submitted standards.

Microscopic Examination

- Cleaning – Remove visible debris from the hair. If necessary, the hair(s) can be sonicated in deionized water to remove any additional debris.
- Mounting – Xylene can be used for a temporary mount and Permount can be used for a more stable mount. Each slide must be properly labeled for identification with the barcode number and case number or property tag and item number, analyst's initials, date, or other unique identifier.
- Observations – Examine the proximal, medial, and distal regions of the hair for the following characteristics:
  - Diameter
  - cortical texture
  - pigment size
  - ovoid bodies
  - pigment location
  - cortical fusi
  - pigment texture
  - cuticle
  - pigment amount
  - buckling
  - pigment color
  - diameter variation
  - medulla
  - condition of tip
  - condition of root

Comparison

In order to conclude that a questioned hair is similar to a known hair standardthere must be no significant differences in the characteristics outlined above. To do this type of comparison, place questioned and known hairs under the comparison microscope and compare side-by-side from root to tip. Document similarities and differences. Note: Both the questioned and known hairs must be mounted in the same mountingmedia in order to make a comparison.In most circumstances, hair fragments are not suitable for comparison purposes. Any comparisons completed are limited in value, due to fragments not being complete and further characteristics may be missing. Any request for possible comparison on questioned hair fragments must be submitted to the Supervising Criminalist. Opinions and Interpretations

- Association – The questioned hair is similar in (color, length, contour, etc.) to the hairs in the submitted standard.

Conditions – The macroscopic/microscopic characteristics of the questioned hair can all be found within the range of characteristics of the hair standard.

- Non-association - Significant differences were noted in the (color, length, contour, etc.) between the questioned hair and the hairs in the submitted standards. Therefore, these hairs are not similar.

  Conditions – The questioned and known hairs show significant, unexplainable macroscopic/microscopic differences.
- Inconclusive - The questioned and known hairs show both similarities and differences such that no clear conclusion can be drawn.
- Suitable for nuclear DNA - The questioned hair contains cellular material and is/may be suitable for nuclear DNA analysis.
- Non-suitable for nuclear DNA- The questioned hair does not contain cellular and is not suitable for nuclear DNA.
  - Note: If the questioned hair is a head or pubic hair it is best to write appears to not be suitable for nuclear DNA analysis.

References

John W. Hicks, “Microscopy of Hair”, FBI, Washington D.C.: 1977.

Richard Saferstein, “Forensic Science Handbook”, Prentice-Hall inc., New Jersey: 1982.

Walter C. McCrone and John G. Delly, “The Particle Atlas, Edition Two” Ann Arbor Science Publishers, Michigan: 1973.

APPENDIX A

Somatic Origin **(reference 2)**

Scalp: head hair; 100 - 1000 mm long, 25 - 125 mm diameter; 0.4 mm per day growth; small root; tapered tip, little diameter variation; various medullation; often with cut tips; may be artificially treated.

Pubic: pudental; 10 - 60 mm long; coarse diameter and prominent diameter variation and buckling; broad medulla; follicular tags common; asymmetrical cross-section twisted and constricted; may be straight, curved, or spirally tufted.

Vulvar: secondary pubic hair; finer and shorter than pubic hair; may be abraded.

Chest: pectoral; moderate to considerable diameter variation; long fine arch- like tip; usually longer than pubic hair.

Beard: facial hair, very coarse; 50 - 300 mm long; large root, irregular structure; often triangular cross-section; complex medullation; blunted or razor cut tip; grows 0.40 mm per day.

Axillary: arm pit; 10-50 mm long, grows 0.30 mm per day; coarse, blunt tip, abraded or frayed; usually straighter than pubic hair; many cortical fusi, sometimes yellow and bleached.

Eyebrow: superciliary; 1cm long, 0.16mm per day growth; curved; relatively coarse for length; smooth curve with puntate tip and large medulla.

Eyelash: ciliary; less than 1cm long; short curved pointed hair.

Limb: leg and arm hair; 3-6 mm long, fine tips, irregularly medullated; often indistinctly andslightly pigmented

Ear: tragi, pinnae; downy.

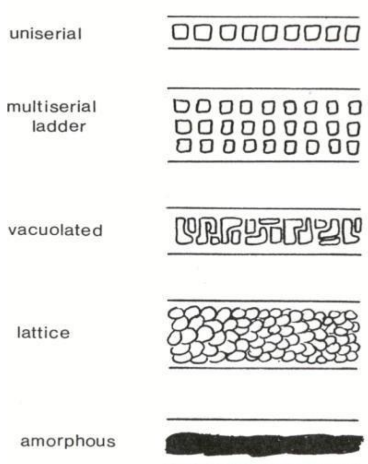
Buttocks: anal hair; short blunted and abraded

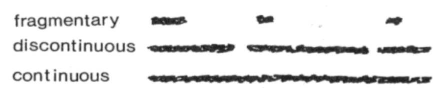
Nose: similar to facial hair

APPENDIX B

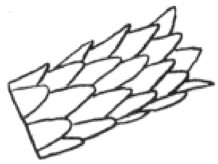
Animal vs. Human Hair Determination (reference 1)

Animal Hair	Human Hair
1. Guard hair and wool hair	1. Uniform hair sample
2. Color banding	2. Even coloration
3. Tapered shaft	3. Even diameter
4. Coarse, structured medulla	4. Thin, thready medulla

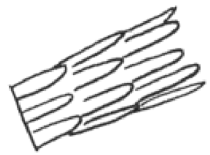




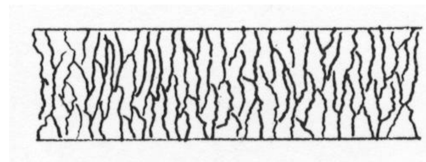
Animal Hair	Human Hair
5. Pigment in or near medulla	5. Pigment away from the medulla
6. Coarse, irregular granules	6. Fine, regular granules
7. Prominent cuticle scales	7. Smooth, flattened cuticle scales



CORONAL



SPINOUS



IMBRICATE

8.	Root shape	8.	Small, regular root
9.	Tapering tip	9.	Tips usually cut or blunt

2.5 IMPRESSION EVIDENCE EXAMINATIONS

MATERIALS AND EQUIPMENT

Materials

- Large plastic dishpan
- Soft bristle brush
- Methanol
- Hydrochloric acid
- Potassium ferrocyanide
- Aerosol sprayers
- Fingerprint powder (black and magnetic)
- Clear adhesive covers
- Identicator Kit – Special sensitized sheets, coater
- Ink
- Fingerprint roller
- Transparency film for plain paper copiers
- Roller transport film
- Silicone lubricant

Equipment

- Scanner
- Light source for oblique lighting
- Appropriate camera equipment
- ALS

PROCEDURES

Special Considerations

- The questioned impressions will be examined prior to examining the known footwear or tires.

Evidence Handling

- Preliminary Considerations – Footwear enhancement techniques can employ chemicals and reagents that are known carcinogens and/or hazardous substances. Therefore, the examiner should read the guidelines published by NIOSH and the Material Safety Data Sheets for all reagents and chemicals that are used.

Collection of Impression Evidence – Impression evidence can be received into the laboratory in many forms. These may include photographs, casts, electrostatic lifts, adhesive lifts, or the item of evidence with the impression on it. The following are guidelines for each of these general types of evidence:

- Photographs – If the impression evidence is in the form of printed photographs or digital images, enlargements of the images to actual size are printed for comparative analysis.
  - The photographs must have been taken from a 90° angle (a tripod is highly recommended) to avoid any size distortion, and a ruler must have been included in the photograph, in the same plane as the impression. The analyst must ensure that the 1:1 enlargement is the correct size by measuring

the ruler in the image against a similar ruler.

- Die Stone Casts - Fill large dishpan with water. Place cast in water and allow loose debris to fall off. Additional cleaning may be accomplished by using a soft bristle brush. Care should be taken not to remove any debris in the sole pattern or alter the pattern in anyway.
- Electrostatic Lifts – If the impression has been collected using an electrostatic lifter, the impression must be photographed immediately. Varying photographic techniques can be utilized to enhance the image, and photographs may be handled extensively while an electrostatic lift should not be.
- Adhesive Lifts – Lifts may be used for comparison purposes as is, or may be enhanced using various image enhancement techniques.
- Item of Evidence - If the evidence with the impression on it is submitted for examination, the impression should be photographed immediately. After photo documentation, various enhancement techniques may be utilized depending upon the type of impression.

Enhancement Techniques - Impressions may be left by a deposition of material (e.g. blood, dust, grease, etc.) or by a removal of material. Depending on the substrate the impression was left on and the material deposited or removed, a number of enhancement techniques can be used. These techniques include:

- Photography - Enhancement through specialized lighting and various photographic techniques is a non-destructive method and therefore, whenever possible, should be attempted first. The use of filters, UV light, infrared light, oblique light etc., are all options for image enhancement. This lab is staged with professional photographers to assist in this type of enhancement.
- Image Enhancement - Images can be enhanced using a scanner equipped with an image enhancement program. By varying the contrast, resolution, and color of the scanned impression, the analyst may be able to enhance the print. In addition, the image may be viewed as a positive or a negative impression.
- Chemical Enhancement - These techniques are destructive and should only be used in the event that all non-destructive techniques have been exhausted.
    1. Impressions made by dust - The enhancement is based on the reaction of $K_4Fe(CN)_6 \cdot 3H_2O$ with iron found in the dust, which gives a blue color. This procedure must be done in a fume hood. Safety glasses, gloves, and a lab coat must be worn.
        a. Prepare a test impression using a non-evidence shoe with a dusty sole by stepping on a sheet of paper.
        b. Mount test print on piece of stiff cardboard with tape or pushpins to prevent curling.
        c. Prepare reagents.
        d. Prepare a 1:1 mixture of $HCl:CH_3OH$ by slowly adding 50 mLs HCl to 50 mLs CH_3OH.
        e. Prepare a 5% $K_4Fe(CN)_6 \cdot 3H_2O$ solution by adding 5.0 grams $K_4Fe(CN)_6 \cdot 3H_2O$ to 100 mLs distilled water. Stir until dissolved.
        f. Using a separate aerosol sprayer for each reagent, spray the $HCl:CH_3OH$ lightly over surface of paper. Allow CH_3OH to evaporate.
        g. Lightly spray surface of paper with ferrocyanide reagent until no further enhancement can be seen.
        h. Dry with warm air.

i. Repeat above steps with evidence impression.
j. Photograph immediately using high contrast photography with a 1:1 scale.

Note 1: Luminol, amido black, and Coomassie blue can be used for enhancement of impressions in blood. The procedures can be found in the Crime Scene Reconstruction and Crime Scene Unit Manuals.
Note 2: Chemical enhancement procedures for other materials may be found in the literature and can be used after in-house validation studies.

Collection of Standards - There are a variety of techniques that can be used to create test impressions. It is important to try and duplicate the type of movement you suspect created the questioned print when making a test print. The shoe should be placed on the analyst's foot and a standing, walking, jumping, running, etc. print can be created. Make test prints of shoes utilizing one of the following techniques:

- Shoes
  - Adhesive lift with powder
    1. Make print using dust or fingerprint powder.
    2. Ensure that shoe sole is completely dry.
    3. Evenly dust with fingerprint powder.
    4. Shake off loose powder.
    5. Remove protective cover from clear adhesive material and press sole of shoe carefully against adhesive surface.
    6. Press adhesive sheet onto all areas of shoe sole.
    7. Peel adhesive away from shoe and place on protective sheet.
    8. If enough dust is initially present on the shoe sole, fingerprint powder need not be used.
  - Identicator Kit
    1. Wash and dry sole of shoe.
    2. Place coater on the floor with a sensitized sheet next to it, treated side up.
    3. Press shoe firmly on coater and coat entire sole.
    4. Press shoe firmly on sensitized paper.
  - Ink and Paper
    1. Using fingerprint roller, deposit ink evenly over sole of shoe.
    2. Make impression on white paper.
  - Roller Transport Film
    1. Ensure that shoe sole is completely dry.
    2. Evenly dust with fingerprint powder.
    3. Shake off loose powder.
    4. Dip sponge into water; wipe sponge over surface of roller transport film to wet.
    5. Use squeegee to remove any excess water from film.
    6. Walk sole of shoe across film, leaving a powder print.
    7. Allow to dry. This technique is best used in conjunction with procedure
       a. Dust sole of shoe, walk across adhesive surface, then walk

immediately across the damp film surface.

- Tires – Tires should remain mounted on the original vehicle with the original air pressure if possible.
  - Ink and white paper stock (exam paper is too thin and will wrinkle as the tire moves over it).
    1. The tire can be rolled or sprayed with ink.
    2. The tire should be evenly coated with ink.
    3. Drive/roll the entire circumference of the tire using a reference point marked on the side of the tire onto white paper.
    4. Label impression with direction tire was traveling, location of tire on vehicle, initials, case number, and date.
  - Fingerprint powder and petroleum jelly
    1. Spray or rub tire with silicone lubricant or petroleum jelly
    2. The entire circumference should be sampled using a reference point marked on the side of the tire.
    3. Drive/roll the entire circumference of the tire over clear colorless polyester sheeting attached to poster board or similar surface.
    4. Powder impression with magnetic powder
    5. Remove excess powder
    6. Spray impression with hair spray or any clear acrylic spray, and allow it to dry
    7. Label impression with direction tire was traveling, location of tire on vehicle, initials, case number, and date.
    8. Take care not to reverse the overlay. Roll the polyester sheet with the impression between exam paper to protect the impression from damage.
    9. Inked tires can be rolled onto clear wet media film. See reference "Tire Tread and Tire Track Evidence."

EVALUATION AND COMPARISON

- Comparison – Using the test impressions and overlays from the suspect shoes and the photographs, die stone casts, or impressions from the scene, the following comparisons should be made.
  - Size, shape, and sole or tread pattern.
  - Wear characteristics and manufacturing defects.
  - Randomly acquired characteristics (cuts, gouges, scratches, etc.).
- Identification of Tire Type – Occasionally, the analyst will be requested to identify the tire or tire types that could have made a questioned impression. At this time, we do not possess any current *Tread Design Guide* books to evaluate the brand of tire.

Opinions and Interpretations

- Identification – the known shoe/tire made the questioned impression.
  Condition - If the class characteristics (size, pattern, and shape) and wear characteristics are similar, and randomly acquired characteristics found on the shoe/tire are reflected in the questioned impression, then an identification can be made.
- Association - The questioned impression is similar in sole/tread pattern, shape, size, and wear characteristics to the known shoe/tire. The known shoe/tire or a shoe/tire of similar size, shape, and pattern could of have made the impression.
  Condition - If class characteristics and/or wear characteristics are similar on the shoe/tire and are reflected in the question impression, however no randomly acquired characteristics are found, an association can be made.
  - Note: If only a few of the class characteristics can be compared and are similar then, the analyst can determine that a limited association exists between the questioned impression and the known shoes/tire.
- Exclusion – The known shoe/tire is excluded from making the questioned impression.
  Condition- If the class characteristics and/or wear characteristics are dissimilar on the shoe/tire to the class characteristics and/or wear of question impression, an exclusion can be made.
  - Note: Analysts must be careful when considering wear characteristics, the time of collection of the known shoes relative to the time of incident is important and should be known prior to analysis.
  - Note: Exclusions can't be made based on wear unless the known shoe is submitted as evidence
- No Conclusion- The questioned impression lacked sufficient details; no conclusion can be made
  Condition - If insufficient details or lack of a proper scale are present with the question impression then no conclusion can be made.
- Inconclusive - The questioned impression is similar in sole/tread pattern to the known shoe/tire. Due to no scale being present, no conclusions can be made on shape, size, and wear. The comparison of the question impression and known shoe/tire is inconclusive. The known shoe/tire cannot be included or excluded from making the questioned impression.
  Condition – If some class characteristics and/or wear are similar and other characteristics are dissimilar or can't be determined then an inconclusive conclusion can be made.

References

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John R. Abbott, "Footwear Evidence", Springfield, Illinois: Charles C. Thomas, 1964. "Tread

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William Bodziak, "Tire Tread and Tire Track Evidence," New York: CRC Press, 2008.

2.6 PAINT ANALYSIS

MATERIALS AND EQUIPMENT

Reagents and Supplies

- Permount
- Xylene
- Acetone
- Chloroform
- DI water
- Diphenylamine reagent
- Forceps
- Tape lifts
- Scraping tool (dull-bladed knife, putty knife/scraper, or similar
- tool)
- Butcher paper
- Petri dishes
- Glass slides
- Coverslips
- Tungsten needles
- Scalpel
- Razor blades
- Diamond compression cells
- KBr
- Graphite sampling mounts for SEM-EDS analysis

Equipment

- Stereomicroscope
- Polarized light microscope
- FTIR microscope and accessories
- SEM/EDS

PROCEDURES

- Evidence Handling/Safety
    - Special Considerations - The analyst must be aware that trace evidence is susceptible to contamination during laboratory examination. The analyst must ensure that the tools, examination area, laboratory coat, and gloves are clean. Each item of should be examined on a new piece of paper.
    - Questioned evidence is examined prior to any known or comparison samples.
    - Separate the examination of questioned and known reference items with by location or by examination of the items at different times.

- Safety
    - Some of the methods described employ dangerous chemicals, temperatures, and radiation. It is the responsibility of the analyst to follow appropriate health and safety practices.

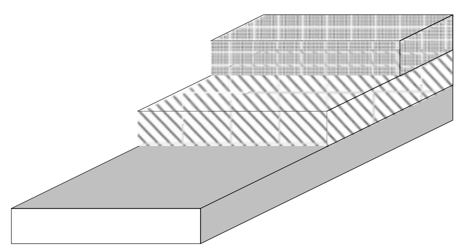
- Evidence Examination
  - General Considerations – Laboratory analysis currently consists of identification and comparison of paint samples. No possible make/model information is provided at this time.
  - It is the goal of this procedure to provide a reasonable approach to paint comparison. The methods referenced in this procedure need to be validated by each analyst. Paint should not be approached with a rigid analytical scheme as each method has strengths and limitations. It is up to the analyst to evaluate both the samples and the analytical technique applied.
  - This method is specific to the analysis of automotive paint. Architectural paint requires different analytical techniques and requires a difference approach. For information regarding the analysis of architectural paints see appendix A.
  - The paint samples should initially be evaluated for the possibility of a physical match. This is the most conclusive association. Edges and surface striae having unique characteristics must be documented using appropriate means.
  - Paint samples are compared by their physical and chemical characteristics. The physical characteristics include color, layer sequence and thickness, and surface and layer features (striations). The chemical characteristics include pigments, binders, and additives.
  - The evaluation and documentation of the differences between known and questioned samples is the focus of paint comparison. The existence of a range of variation in samples of a known source needs to be recognized. The examiner's goal is to assess the significance of any observed differences. The absence of significant differences implies a common origin. The strength of association determination is dependent on the type and number of corresponding features.
- Collection/Documentation of Evidence
  - Sketch and/or photograph the item of evidence, note any damage and the location of obvious paint transfer.
  - Questioned sample – Obtain all loose or transferred paint materials. Sources can include tools, floors, walls, and glass transfers on vehicles or individuals. The following collection techniques should be utilized.
    - Stereoscopic examination and particle picking – Search for paint chips on clothing near compressed fabric (impact areas). Often the paint evidence from hit and run cases will be melted or smeared onto fabric. Smeared transfers should be collected with the underlying layers or object. It is preferable to recover intact paint chips. Use forceps to recover visible chips.
    - Scraping – This is a good recovery technique for paint evidence that was not collected using a stereoscope and forceps. Place a clean piece of butcher paper under the article to be scraped. Using a dull bladed knife, wall scraper, or similar tool, scrape the surface of the item of evidence (clothing) onto the paper. Transfer scraping into a petri dish and examine using a stereoscope.
    - Tape lifts – Every effort should be made to collect the paint evidence

manually before the application of tape lifts. The adhesive could cause contamination of the paint. After the above-mentioned techniques have been utilized, the analyst may choose to collect any remaining trace evidence utilizing tape lifts. These tape lifts may then be examined using a stereomicroscope.

    - Known sample
        - The analyst should obtain samples from areas as close as possible to the damaged area (outside the actual transfer area). The possibility of two-way transfers (between two coated surfaces) should be considered. Samples of both surfaces should be collected. Collect samples by prying/scraping particles from the surface into a paper bindle using a scalpel or razor blade.

- Analytical Techniques
    - Prior to the instrumental analysis of a paint sample, the analyst must determine if the unknown paint particles are consistent with automotive paints. The following observations may be helpful in determining what type of paint you have.
        - Automotive Paints
            - High gloss
            - Hard but not brittle in texture
            - Metallic flake in base (color) coat
            - Multiple layer coating systems
            - Body fillers and spot putties
        - Architectural Paints
            - Latex Finishes
                - Often medium to low gloss.
                - Rougher surfaces, even in gloss finishes
                - Less homogeneity in the pigment distribution
                - Flexible texture which tears with tensile force
                - Multiple layers are usually not coating systems
            - Oil Based Finishes
                - Often hard thin single layered fragments.
                - Often high gloss with rougher surfaces.
    - The most conclusive statement regarding the relationship between questioned and known samples is that of a fracture match. Examine questioned and known chips for a possible physical match before any other tests are performed.
- Microscopy
    - Examine the size, color, gloss, texture, number of layers, and layer sequence of the questioned and known paint samples under a stereoscope. Identify the layers by viewing the sample edges with an optical microscope at magnifications between 5x and 100x. Top illumination without mounting will reveal the layers. To identify layers and perform instrumental analysis, the sample must be prepared as follows:
        - Paint Sample Preparation
            1. Work with a new scalpel blade

2. Place chips on a microscope slide, or hold chips in place using a post-it note
3. Sample each layer using repetitive very thin peels working your way through each layer. Start with the topcoat facing down, peel from the primer side.
4. Make thin peels by holding chip down with forceps and use a scalpel blade to provide a shaving action toward the tweezers.
5. Use middle, ring, and little fingers to rest on the countertop providing steady support for the scalpel. Guide the blade with the index finger and thumb.
6. Always take thin peels to avoid pressure on the chip's layer interfaces.
7. For small chips that do not permit placement of forceps on top of the chip, use a blocking technique with dull forceps.
8. On extremely difficult samples, try a cross section peel.
9. Save any peels generated for other examinations microchemical, IR, etc.
10. Resulting chip should have a stair step shape. This chip can be utilized for SEM analysis of the individual layers.

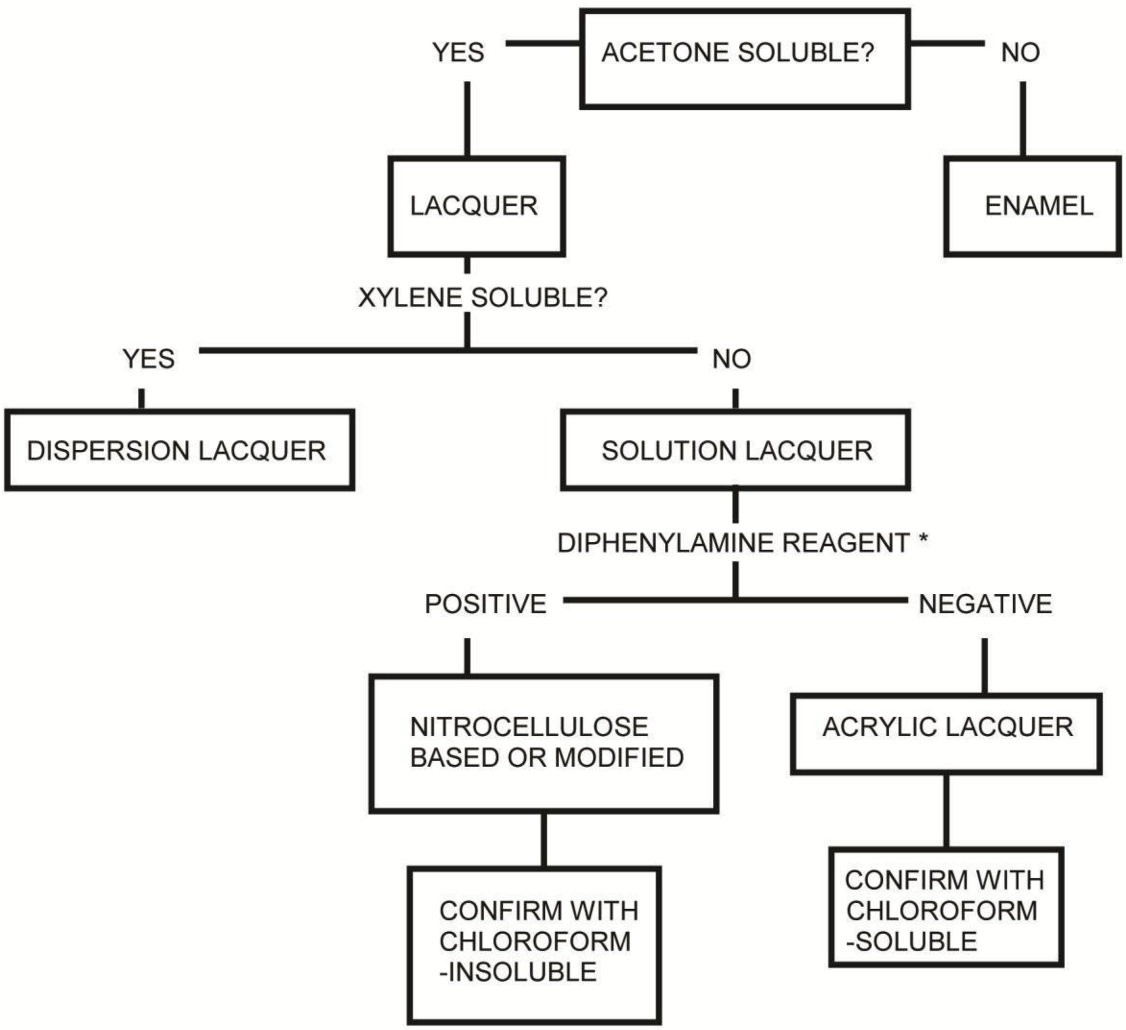


- Use a microscope to perform side by side comparisons of known and questioned sample layers. Both samples need to be positioned side by side in the same field. This is necessary due to illumination difficulties encountered with a comparison scope.
- Use polarized light microscope to characterize the inorganic pigments based on their morphology and optical properties. The analysis can examine thin peels, pyrolysis residues, sublimation condensates (see D. Crown's book) and dispersed particles. Tease the paint with a tungsten needle and observe the pigment granules. The size, shape, transparency, homogeneity, pleochroism, and relative indices can be observed with plane polarized light. Isotropy, anisotropy, retardation, birefringence, extinction, sign of elongation, and extinction colors can be views with crossed polars (see

McCrone's Particle Atlas).

- Chemical/Solubility Tests
    - If sufficient paint is available, destructive chemical testing may be performed. Automotive paint chips (individual layers) can be easily classified as lacquers or enamels. Lacquers can be differentiated into dispersion or solution lacquers. Thornton's solubility scheme provided below may assist in determination and classification of original versus refinish automotive paints.

Basic Microchemical Scheme for Automotive Paints



*Note: To perform DPA microchemical test, take a particle of paint, place on a microscope slide, and add one drop of acetone and allow to dry. Paint pigments will tend to remain towards the center of the dried drop, while the binder will have traveled away from the center along with the acetone. Add one drop of the DPA reagent. An immediate blue color indicates the presence of nitrocellulose.

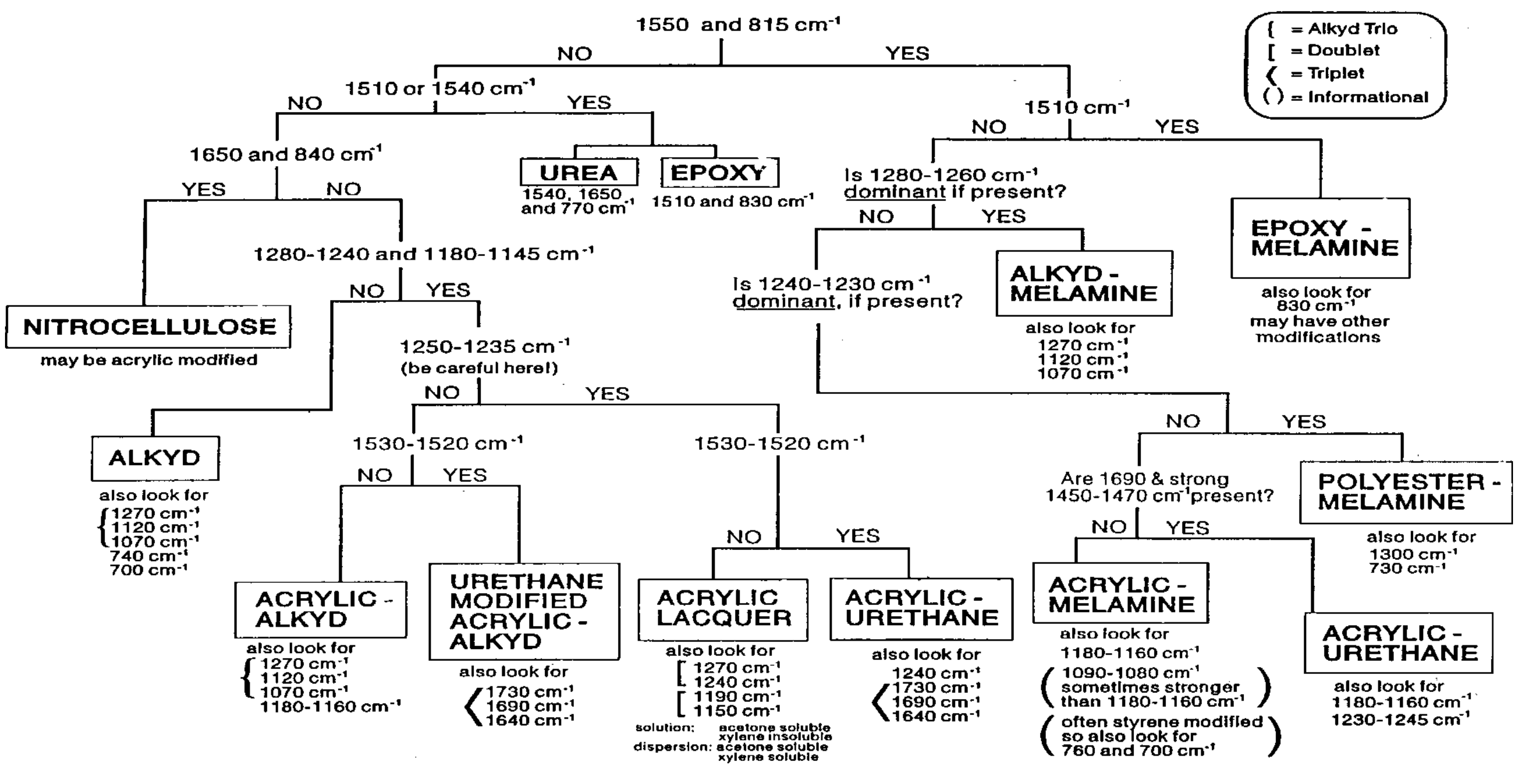
DPA Reagent: Dissolve 0.3 grams of diphenylamine in 20 mLs concentrated H_2SO_4 and 10mls of glacial acetic acid.

- FTIR
  - Classification of paint chip binders is achieved using Micro- FTIR. Each layer should be analyzed separately to provide the most information. The proper aperture must be applied to minimize stray light and to provide the greatest sensitivity for analysis. The FTIR microscope can be used in the transmittance mode or by utilizing an ATR objective. For the most accurate results, run multiple analyses on each layer to achieve reproducible spectra. Automotive finish coats can be classified using the "Automotive Paint Binder Infrared Classification Flow Chart" authored by Tillman. Extender and color pigments may contribute to the paint spectrum.
  - *Typically Encountered Coating Binders*
    - Alkyds
    - Polyesters
    - Acrylics
    - Urethanes
    - Epoxies
    - Cellulosics
  - General Approach to Binder Classification By IR
    - Determine if paint chip is lacquer or enamel by microchemical solvent examination.
      - If paint is a lacquer, determine the type by microchemical examination.
        - Acrylic Solution Lacquer
          - acetone soluble
          - xylene insoluble
          - DPA negative
        - Acrylic Dispersion Lacquer
          - acetone soluble
          - xylene soluble
          - DPA negative
        - Nitrocellulose Lacquer
          - acetone soluble
          - xylene soluble
          - DPA positive
      - If paint is an enamel, determine the type by IR.
        - Look for melamine cross-linking (1550 cm^{-1} and 815 cm^{-1}) found in original finishes.
        - Look for urea cross-linking (1650 cm^{-1}, 1540 cm^{-1}, and 770 cm^{-1}). Typically found in primers, not in finish coats.
        - Look for epoxy cross-linking (1510 cm^{-1} and 830 cm^{-1}). Found mostly in primers.
        - Look for urethane modification (1530 – 1520 cm^{-1} and possible "stair step" on carbonyl 1730 cm^{-1} at 1690 cm^{-1} and 1640 cm^{-1}. "Newer generation" paints have doublet at 1730 cm^{-1} and 1690 cm^{-1} with intense band at 1460 cm-1).

- Look for MAJOR broad band in the 1300 cm^{-1} to the 1000 cm^{-1} region.
    - Acrylic – 1150 cm^{-1} to 1180 cm^{-1}
    - Alkyd – 1260 cm^{-1} to 1280 cm^{-1}
    - Polyester – 1235 cm^{-1} to 1255 cm^{-1}
- Always check peak tables of respective binders to confirm other absorption bands.

(Classification Chart follows)

AUTOMOTIVE PAINT BINDER INFRARED CLASSIFICATION FLOW CHART



- SEM/EDS
    - The SEM/EDS can be used to analyze the pigment portion of the sample. Multiple areas or large areas will give representative spectra. The chip can be edge mounted in a vertical orientation. As an alternative, the chip can be beveled to reveal the layers. Individual layer analysis is preferred.
    - The SEM/EDS system must be run on low-vacuum to avoid charging for all paint samples. (See GSR method for more details on how to use SEM/EDS)
    - Open point and ID system in Aztec program of the EDS, ensure process time is changed to 5
    - Run a quality control sample
        - A stub containing known salts will be run
        - All salts must be properly identified
        - Results will be saved and part of note packet
    - Run the samples
    - Commonly Encountered Extender Pigments
        - Silicates
            - Quartz Si
            - Diatomaceous earth Si
            - Synthetic Silica Si
            - Kaolin (China Clay) Al, Si
            - Bentonite Al, Si
            - Talc Mg, Si
            - Asbestine Mg, Si K,
            - Mica (Muscovite) Al, Si
            - Mica (Phlogopite) K, Mg, Al, Si
            - Wollastonite Ca, Si
            - Synthetic Calcium Silicate Ca, Si
        - Sulfates Ca, Si
            - Barytes Ba,S
            - Blanc Fixe Ba,S
            - Gypsum Ca, S
            - Precipitated Calcium Sulfate Ca, S
            - Calcium Sulfate Anhydrite Ca, S
        - Carbonates
            - Precipitated Calcium Carbonate Ca
            - Calcite Ca
            - Limestone Ca
            - Aragonite Ca
            - Dolomite Ca, Mg

    - Commonly Encountered Coloring Pigments
        - Inorganics
            - Ferric Oxide Fe
            - Lead Oxide Pb
            - Yellow Iron Oxide Fe
            - Chrome Yellow Pb, Cr, S
            - Titanium Dioxide Ti

- Lead Chromate — Pb, Cr
- Zinc Iron Ferrite — Zn, Fe, Ti
- Molybdate Orange — Mo, Pb, S, Cr
- Chromium Oxide — Cr
- Zinc Oxide — Zn

- Organics
  - Phthalocyanines — Cu and Cl or Br
  - Nickel Azo Yellow — Ni, Cl

- Architectural Paints
  - General Considerations
    - Architectural paints occur infrequently in forensic casework. These paints are examined using a slightly different analytical scheme. Overall collection and instrumental techniques remain the same. Areas of differing techniques are outlined below.
  - Macroscopic Examination
    - Latex Finishes
      - Often medium to low gloss.
      - Rougher surfaces, even in gloss finishes.
      - Less homogeneity in the pigment distribution.
      - Flexible texture which tears with tensile force.
      - Multiple layers are usually not coating systems.
    - Oil Based Finishes
      - Often hard thin single layered fragments.
      - Often high gloss with rougher surfaces.
  - Microchemical Tests
    - Add one drop of chloroform to an unknown paint chip on a microscopic slide. If the paint chip becomes tacky and sticks easily to your forceps that is indicative of a latex paint.
  - FTIR
    - Typically Encountered Coating Binders
      - Latex Systems
        - Polyvinyl Acetate-acrylic
          - 1735 cm^{-1}, 1370 cm^{-1}, 1240 cm^{-1}, 1175 cm^{-1}, 1135 – 1020 cm^{-1}, 945 cm^{-1}, 605 cm^{-1}
        - Acrylic
          - 1730 cm^{-1}, 1370 cm^{-1}, 1240 cm^{-1}, 1170 – 1150 cm^{-1} (dominant)
        - Styrene-Butadiene
          - 1450 cm^{-1}, 1495 cm^{-1}, 1600 cm^{-1}, 1730 cm^{-1}, 760 cm^{-1} (very strong), 700 cm^{-1} (very strong)
      - Oil-Based Systems
        - Alkyd Enamels (ortho)
          - 1730 cm^{-1}, 1270 cm^{-1}, 1120 cm^{-1}, 1070 cm^{-1}, 645 cm^{-1}, 710 – 705 cm^{-1}
        - Alkyd Enamels (iso)
          - 1730 cm^{-1}, 1235 cm^{-1}, 1300 cm^{-1}, 730 cm^{-1} (strong),

1605 cm^{-1}

- Urethane Enamels
  - 1730 cm^{-1}, 1530 cm^{-1}, and 1240 cm^{-1}
- Nitrocellulose and Acrylic Lacquers
  - (see references)
- Acrylic Enamels
  - (see references)

SEM/EDS – see list of extender pigments in Automotive section.

Opinions and Interpretations

- Identification/Physical Match- The questioned sample was once joined with the known piece of paint
  Conditions- The paint from a questioned sample physically matches the standard paint sample.
- Association – The questioned sample and known or standard paint could share a common source
  Conditions – all microscopic, microchemical, and instrumental comparisons revealed the questioned sample indistinguishable from the known or standard paint.
  - Note: Consider factors such as sampling, loss of layers, different paint system on different parts of the sample vehicle, and limited samples such as monolayer smears. The analyst can determine the nature of the sample and significance of the association.
- Elimination – The questioned sample and known samples do not share a common source
  Conditions – microscopic, microchemical, and instrumental examination reveal dissimilarities in layer structure, layer colors, and/or chemical composition.
- Inconclusive – The questioned and known samples show both similarities and difference such that no clear conclusion can be draw.
  Conditions – The analyst is unable to identify a sample or do a meaningful or extensive comparison due to the small sample size, possible environmental decomposition, or other uncontrollable factors.
- Investigative on make and model
  - After examination using microscopic, microchemical, and instrumental analysis, the red debris on the victim's clothing was found to be consistent with red colored, multi-layered automotive paint. This laboratory can provide no possible make/model information at this time.

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2.7 PHYSICAL MATCH ANALYSIS

MATERIALS AND EQUIPMENT
- Camera
- Stereoscope
- Casting media
- Tape, putty, or other adhesive
- SEM/EDS

PROCEDURE

General Guidelines
- Items submitted for physical match analysis include a wide variety of materials. The Supervising Criminalist shall assign a Criminalist to each physical match case based on the type of examination requested and the instrumentation and expertise required to perform the analysis.
- When pieces can be fit together, the Criminalist can say with certainty that the matching pieces were at one time a single unit. No further analysis is required.
- For items in which a physical match is not found, other examinations or comparisons may be performed.
- The questioned items will be examined prior to examination of the known item.

Examination
- Visually examined each questioned item of evidence to determine its class characteristics (e.g., size, color, pattern, dimension, composition, etc.) and compare the questioned items for similarities.
- Orient the pieces and determined if they have broken/fractured edges that physically fit together.
- Fabric matching involves examining the general size and shape, weave/knit type, fiber type and twist, colors, and patterns, long versus short threads, unusual stretching or contours, stains, damaged area, and stitched edges or selvedges.
- When matching flexible materials (e.g., fabric, tape, and some plastics), care must be taken to account for edge rolling, stretching, and twisting.
- Matching of rigid materials involves examining the general size and shape, colors and patterns, edges and contours, cracks, breaks, and other damaged areas.
- If the edges on the pieces physically fit together, observe all orientations of the physical match for specific, individual, characteristics (e.g., scratches, striations, inclusions, and stains, defects, hackle marks, etc.) that traverse the broken, cut, or torn edges.
  - If comparisons at the microscopic level are necessary, a stereomicroscope, comparison microscope, and/or SEM shall be used.
  - Castings of samples may aid in the comparison. Any suitable casting media may be used, such as mikrosil.
  - Photographs shall be taken of all physical matches.

If sufficient individual characteristics are present, it can be concluded that the items physically match. All reported identifications shall be verified by a second qualified criminalist who will conduct a verification from the original evidence. If the initial authorized Criminalist has reconstructed the material for the fracture match, it may be left assembled for the verifying authorized

Criminalist.

Opinions and Interpretations

- Identification – The questioned item was once joined with the known item to form a single item
  Conditions – Both class and individual characteristics match and the pieces fit together.
- Inconclusive – The physical match analysis of the items is inconclusive
  Conditions – The class characteristics are similar, but there is very limited detail in the break/fracture area.
- Negative – The questioned item was excluded as being at one time joined with the known item.
  Conditions – The class characteristics are dissimilar between items
- Association of class characteristics, but no physical match – The questioned item is similar in class characteristics to the known item, but no physical match was found.
  Conditions – The class characteristics are similar between items, but the edges of the items do not match or could not be analyzed. The items could go on for further analysis and comparisons.

SAFETY

Broken edges can be sharp. Care shall be exercised during this technical procedure.

REFERENCES

ASTM Standard E2288, 2003, "Standard Guide for Physical Match of Paper Cuts, Tears, and Perforations in Forensic Document Examinations." ASTM International, West Conshohocken, PA, 2003.

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Bradley, M.J., et al. "A Validation Study for Duct Tape End Matches." *Journal of Forensic Sciences* 51.3 (2006): 504-508.

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2.8 GSR ANALYSIS

MATERIALS AND EQUIPMENT

Materials

- Specimen holders
- Aluminum stubs 1/2'" x 1/8" pin
- Carbon conductive tabs 12mm diameter
- Disposable gloves
- SDPD evidence seals
- Disposable alcohol wipes
- SDPD Gunshot Residue Evidence kit printed envelopes
- Labels
- Kraft paper
- Tungsten standard filaments
- Cobalt/Rhodium Stub
- Known GSR QC stub

Equipment

- Scanning Electron Microscope with Energy Dispersive X-ray spectroscopy (SEM/EDS)
- Stereomicroscope

SAFETY

The Wehnelt cap is extremely hot. Do not remove with hands. Use appropriate tool to remove Wehnelt cap from electron gun.

Be careful to not ram the stage of the SEM into the microscope causing damaging to microscope. The Z should be moved when exchanging samples and should never go below 11 with a working distance of 10.

PROCEDURES

GSR Collection Kits

- Place the carbon conductive tabs on top of the aluminum stubs.
- Place the stubs into the specimen holders
- Place the following items into each SDPD GSR printed envelopes:
    - One evidence seal
    - One disposable alcohol wipe
    - One pair of disposable gloves
    - One folded piece of clean Kraft paper
    - Two stubs in specimen holders
        - Label the stubs with right or left hand and the corresponding kit number
- Vehicle kits will be assembled within each batch
    - Vehicle kits will contain four unmarked stubs only
- Label the SDPD GSR envelope with the kit number. Ensure it is the same label number as the stubs in the envelope.
- Seal the envelope with a small piece of transparent tape.

- Each batch with have one kit for QC
    - The QC kit will be analyzed and must contain no two component or three component particles

Clothing Sampling

The following items will not be tested for primer gunshot residue, unless there are specific circumstances:

- Inner clothing items such as undershirts, underwear, bra, socks etc.
- Sneakers

Procedure:

- Place item of clothing to be examined on a clean white sheet of paper
- Label stub with case identifier and location of sampling
- Press adhesive stub on the area to be sampled until the adhesive loses stickiness
    - More than one stub may be needed to sample a clothing item
- Store stubs in holders labeled with case number, barcodes, and area sampled

If other objects or items are submitted for GSR sampling, the analyst should use their discretion and expertise on the best areas to sample. Follow the same procedure as the clothing sampling.

Generally, the Trace unit will not process GSR victim kits. When considering a victim of a gunshot wound, it is a known fact they already fall into what we describe as a Gunshot Residue environment. Any further analysis on these types of stubs DOES NOT provide additional information than what is already known from the case scenario. However, with a Crime Lab Supervisor's approval, a GSR victim kit can be processed with a written request made by the District Attorney's office, or if a Supervising Criminalist deems it appropriate based upon case scenario.

GSR Kits

- Open kits one at a time
- Label each stub with a case identifier
- Record the information provided on the envelope onto the information sheet
- Make a copy of the envelope for case notes
- Examine stubs with stereomicroscope and record observations
    - If debris on the stub could interfere with the electron beam run in Low Vacuum mode

SEM/EDS Analysis

- Vent the instrument
- Place the marked stubs into the sample holder, and note what location on the holder the sample was placed in
    - Note: only stubs from a single individual can be analyzed at a time
- Pump down the instrument into either High Vacuum or Low Vacuum (25 Pa) mode
- Turn on the filament
- SEM parameters
    - Working distance: 10mm
    - Accelerating voltage: 20kV
    - OL Aperture: 3
    - Magnification: 300x
- Create a database for the sample using the GSR recipe – print the recipe for the case

packet

  - Process time: 4
  - First Pass: 2 Second pass: 3
  - Spectrum range: 0-20Kv
  - 2000 Channels
  - Field setup: 1024 x 768
- Complete the quant calibration on the cobalt stub
  - Run two consecutive tests and save results

- Make sure the resolution is less than 150kV
    - Record the resolution in the logbook
- Set the threshold on the cobalt and rhodium standard at 128 and 255
    - This area is examined every 30-60 minutes during an automated run
- Threshold for feature detection should be set to 64 and 255
- Run the quality control
    - A field of a known gunshot residue stub is run
    - A pre-determined three component particle under 1.0µm must be located
    - Save data and place in case packet
- Choose the Area Layout for the samples
    - Edit and save the Z for each stub
- Once all samples are set-up and put into the batch set up, start the run
- Notes:
    - Stubs do not need to be run to completion if the analyst confirms the presence of characteristic particles
    - All stubs from an individual do not need to be run if the analyst confirms the presence of characteristic particles on a stub from the individual

Manual Confirmation of Particles

- Relocate any potential GSR particles detected during the automated analysis
- Acquire an x-ray spectrum for the confirmed particles
- If no GSR-related particles are detected on the stub, ensure the focus and general operating conditions have not varied
    - If changes have occurred, the automated analysis should be performed again

Classification of Particles

- All gunshot residue particles must have a non-crystalline morphology
- Characteristic particles contain:
    - Lead, Antimony, and Barium
    - Lead, Antimony, Barium, and Tin
- Consistent particles contain:
    - Barium and Antimony
    - Lead and Antimony
    - Lead and Barium
- Other additional components may be present in the particles from the primer composition, other ammunition components, or from the firearm itself.
- Some older and specialty ammunition may not contain one or more of the three typical elements. If this is the case, a comparison to the ammunition can be completed by sampling one of the two different ways:
    - A barrel swab of the firearm in question can be sampled with a GSR stub
    - An expelled cartridge case of the ammunition can be scraped with a woodenapplicator, and the wooden applicator can then be sampled with a stub.
    - The stubs are analyzed with the SEM/EDS
    - NOTE: Ammunition and barrel swabs are not examined in the chamber with other samples
- No characteristic particles (negative) could be due to many factors:
    - The individual did not fire, handle, or was in close proximity to the discharge of a firearm, or contact a surface contaminated with gunshot residue.
    - Hands or clothing was washed

- Hands were wiped
- Gloves were worn
- Hands or clothing were sweaty
- Environmental factors including wind and rain
- Lots of debris or blood on hands
- Normal activity before sampling (4-6+ hours)
- Weapon did not produce primer residues
- Physical barrier at time of discharge

Opinions and Interpretations

- Information provided in all gunshot residue kits reports:
  - Gunshot residue will remain on the hands for approximately 6 hours or less with normal activity. Gunshot residue may be deposited on the hands from handling, firing, or being in close proximity to the discharge of a firearm, or by contacting a surface contaminated with gunshot residue. The absence of gunshot residue does not eliminate an individual from involvement with a firearm.
- Information provided in all clothing or other object reports:
  - Gunshot residue may be deposited on an item from being in close proximity to the discharge of firearm, or by contacting a surface contaminated with gunshot residue. The absence of gunshot residue does not eliminate an individual from involvement with a firearm.
- For gunshot residue kits:
  - Characteristic
    - The subject had exposure to gunshot residue through one of the means described above.
  - Negative
    - No conclusion can be drawn from the result of this sample.
- For clothing or other items:
  - Characteristic
    - The item had exposure to gunshot residue through one of the means described above.
  - Negative
    - No conclusion can be drawn from the result of this sample.
- Ammunition comparison
  - Similar
    - The particles from (kit, clothing, or item) are similar in elemental composition to the known ammunition or barrel swab. The particles could have come from the known ammunition or firearm or any other with similar elemental composition.
  - Dissimilar
    - The particles from (kit, clothing, or item) are dissimilar in elemental composition to the known ammunition or barrel swab. No conclusion can be made from this sample.

3.1 REPORTING

Refer to the laboratory general policy for the standardized laboratory report format, case notes, technical review, and administrative review requirements. Trace Evidence Unit reporting policies are included in at the end of each method policy document.

CASE NOTES

Case notes requirements follow the requirements stated in the laboratory quality assurancemanual for technical records.

ABBREVIATIONS

- SEM/EDS or SEM/EDX: Scanning Electron Microscope with Energy Dispersive X-ray Spectroscopy
- GC/MS: Gas Chromatography with Mass Spectrometry
- GC-FID: Gas Chromatography with Flame Ionization Detector
- FT-IR: Fourier Transform Infrared Spectroscopy
- IR: Infrared
- PLM: Polarized Light Microscope
- Stereo: Stereoscope
- GSR: Gunshot Residue
- C-strip: Activated charcoal strip
- ACS: Activated charcoal strip
- n: Refractive index
- $n_{||}$: Parallel refractive index
- $n_{\perp}$: Perpendicular refractive index
- Birefrig or B: Birefringence
- Sign: Sign of elongation
- Delust: Delusterants
- BC: barcode
- X-section or XS: Cross-section
- LPD: light petroleum distillate
- MPD: medium petroleum distillate
- HPD: high petroleum distillate
- Poly: polyester
- Std: Standard
- TLC: Thin Layer Chromatography
- UV: Ultra violet
- R_f: Retention Factor
- Trans: Transmitted light
- Ref: Reflected light
- Mod: moderate
- Sl: slightly
- Dk: dark
- Lt: Light
- Inc: Incident
- PT: Property Tag
- Macro: macroscopic

- Micro: microscopic
- MP: melting point
- BP: boiling point
- Nyl: nylon
- Neg or -: negative
- Pos or +: Positive
- App: Apparent
- Recv'd: Received
- Cont'd: Continued
- Pass.: Passenger
- Diam or dia: Diameter
- Chem'l: chemical
- Brn: brown
- w/: with
- blk: black
- approx.: approximate or approximately
- app: apparent
- RF: right front
- LF: left front
- RB: right back
- LB: left back
- LV: low vacuum
- Pass or Passen: passenger
- Brn: brown
- Blk: black
- IL: ignitable liquids
- Sol'n: solution

STATISTICS

- Each analyst will generate a statistical report for each case worked. This includes proficiency tests. The statistical report will contain the following information:
    - Criminalist:
    - Unit: Trace Evidence/Case Type
    - Case (Key Case Number):
    - Number of Cases Involved:
    - Number of Items Examined:
    - Number of Reports:
    - Comments:
- Each case will count as one case. Each item examined will count as one item. Each report generate will count as one report. The statistical report will be included with the report for the Supervising Criminalist to review. The Supervising Criminalist will keep the statistical report and use them for monthly unit statistical reports.

TECHNICAL REVIEW AND ADMINSTRATIVE REVIEW REQUIREMENTS

Technical review and Administrative review requirements follow the requirements stated in the laboratory quality assurance manual for technical records.

4.1 EQUIPMENT INFORMATION

The following equipment is specific for Trace Evidence:

- Scanning Electron Microscope-SEM with Energy dispersive X-ray analysis system
- Fourier-Transform infrared Microscope- FTIR microscope with data system
- Polarizing microscopes
- Stereomicroscopes with illuminators
- Transmitted Light Comparison Microscopes
- FID Gas Chromatograph with data system
- Gas Chromatograph/Mass Spectrometer
- Reference collection of hairs, fibers, accelerants, glass, etc.
- Open pan balance

EQUIPMENT GENERAL USE

The following equipment has the following general uses:

- Scanning Electron Microscope-SEM with Energy dispersive X- ray analysis system
  - gunshot residue and identification of inorganic particles and residues
- Fourier-Transform Infrared Microscope with data system
  - fiber analysis, paint analysis, explosives, tapes, polymers, unknowns, and identification
- Polarizing Microscopes
  - hair and fiber analysis, paint analysis, explosives, general trace evidence unknowns
- Stereomicroscopes with Illuminators
  - preliminary evidence evaluation
- Transmitted Light Comparison Microscopes
  - Side-by-side, microscopic comparison of trace evidence materials
- FID Gas Chromatograph with data system
  - ignitable liquid identification
- Gas Chromatograph/Mass Spectrometer
  - ignitable liquid identification and general organic analysis
- Open pan balance
  - weight of reagents and samples

5.1 QUALITY ASSURANCE MEASURES

GENERAL
- Any errors or issues will be reported to the Technical Lead. The Technical Lead will track and maintain records of all issues and errors within the Trace Evidence Unit.

PROFICIENCY TESTING
- Proficiency testing is completed on a cycle according to the lab Quality Manual. Proficiency Tests are completed as independent casework, following unit policies and procedures. Test results will be evaluated against published results, with consideration to unit policies and procedures, by the Latent Print Supervisor, or OCA, using the Proficiency Test Record form. The Technical Lead will assist to evaluate the results if there is a difference between the publish results and individual examiner's result. If an examiner is unable to complete the test due to poor quality of the issued test samples, the examiner will confer with the unit supervisor to determine the course of action.

SECONDARY CHEMICAL CONTAINERS
- Secondary containers hold chemicals that have been transferred from a primary container. Secondary containers must be labeled according to the laboratory safety requirements to contain: chemical name, signal word, and pictograms. These labeling requirements are exempt if the material is used within the work shift of the employee who makes the transfer.

REAGENT TESTING
- A reagent is a chemical substance added to a solution of another substance to produce a chemical reaction, so as to detect, measure, or produce other substances. Reagents prepared by the Trace Evidence unit will be labeled to contain: reagent name, signal word, pictograms, and preparation date. These labeling requirements are exempt if the regent is used within the work shift of the employee who prepares the reagent.
- Reagents will be tested upon preparation to verify contents. Appropriate standards and controls will be run to assure proper working condition. The date of preparation and the results of the standards and controls will be recorded in the case notes.

GSR KITS
- One random kit from each assembled batch will be tested using the automated SEM/EDS GSR method
- No three component GSR or two component GSR particles should be found
    - If three component GSR or two component GSR particles are found the entire batch can't be used
    - Analysis of contamination and the source should be determined
- Retain all records

FIRE DEBRIS QA/QC

Materials and Supplies
- Reagent grade or higher (ACS specifications) chemicals will be used in all tests.
- All materials used must be checked for possible contamination or interferences on a regular basis. These materials include:

    - Evidence containers used for analysis of fire debris evidence in the Laboratory by scene investigators (metal paint cans and Kapak bags).
    - Materials used in the laboratory for the actual extraction of accelerants, e.g. charcoal strips, solvents, syringes, and sample vials.
- These materials will be tested for the presence of hydrocarbons or other compounds that may interfere with the detection of volatiles.
    - Solvents will be analyzed frequently by direct injection onto the GC column being used.
    - Evidence storage containers will be checked on a batch basis by using passive-adsorption/elution with charcoal strips. Metal paint cans are purchased by the investigators and are submitted to the laboratory when new lots are received. A report of pass/fail is provided to the investigators as to whether or not the new cans are suitable for evidence collection.
- In the event that hydrocarbons or other interfering substances are detected the contaminated item(s) will be identified and removed from use in analysis and replaced with non-contaminated material. In the event that the metal evidence cans contain interfering substances, the investigators will be notified to purchase a new lot of cans.

Accelerant Reference Library

- A library of reference samples and chromatograms is maintained in the unit. Each reference is uniquely identified and include many different commercial products. The samples can be analyzed as neat liquids, liquids diluted in an appropriate solvent, and/or adsorption/elution depending on the analytical conditions expected to be used for the analysis of actual case samples. Obtain reference chromatograms under standard GC conditions and display at the lowest attenuation so that all peaks remain on scale. The library should include the following:
    - Class 1 - Neat samples of products found in this classification (lighter fuels, rubber cement solvents, petroleum ether) including various brands or sources.
    - Class 2 - Gasolines (automotive) of several brands and grades. Run neat, 50 - 70% evaporated, and 95 - 98% evaporated.
    - Class 3 - Neat samples of the products typical of this class (paint thinners, charcoal starters, torch fuels, mineral spirits), including various brands and sources.
    - Class 4 - Any brand or grade of kerosene, run neat, Jet A (Aviation, JP-5), insect sprays.
    - Class 5 - Fuel oil No.2 (diesel fuel).
    - Class 0 - Neat samples of alcohols, ketones, aromatics, isoparaffinic solvents, camping fuels, lacquer thinners, carburetor cleaners, duplicating fluids, gum turpentines, etc.
- The accelerant references are stored in a freezer. The temperature of storage of the accelerants is non-critical, and only done to help with evaporation; therefore, the temperature of the freezer is not recorded.

INSTRUMENTATION

General

- All data from the instruments is stored on the individual instruments under the case or incident number. The data is also printed out and saved as a hard copy in each case file.

Equipment Performance Evaluation

- A logbook will be maintained for each instrument in which maintenance is performed. All instruments will complete the appropriate performance check before returning to service. For the appropriate performance check refer the instrument sections bellow.

GC/MS and GC-FID

- A commercially available and traceable resolution test mixture will be run with every run. The following criteria must be observed with the resolution test mixture sample:
    - Twelve peaks
    - The peaks must be clearly separated
    - The peaks must be sharp with no baseline issues
- Routine maintenance of the analytical equipment must be performed in accordance with the manufacturer's recommendations. For GC/MS and GC-FID this will include properly servicing the columns, gases, detectors, and injectors.
- The proper settings needed will depend on the specific equipment and column in use. However, the performance of the column will be checked against a reference chromatogram of resolution test mixture. The column and program together should allow baseline resolution of all components of such a mixture. If all components cannot be resolved, adjustments to the chromatography run parameters needs to be made to achieve proper resolution. A printout copy of the reference standard run will be filed in the GC-FID and GC/MS logbook.
- A commercially available and traceable resolution test mixture that includes n-alkanes will be run every time there is significant maintenance on the instrument that could alter our retention times and after the yearly preventative maintenance service.
- Gas Chromatograph/Mass Spectrometer performance is checked by manufacturer established autotune methods. The following criteria must be observed with the autotune:
    - The relative peak heights from largest to smaller are 69, 219, 131, and 502
    - The peak height ratios should correspond to the ranges outlined within the GC/MS program
    - The multiplier must be below 2300

Stereomicroscopes and microscopes

- Microscopes and stereomicroscopes are covered by the equipment maintenance policy in the laboratory quality assurance manual.

Balances

- Balances are checked quarterly for performance. They are also serviced annually.

FTIR

- To evaluate the performance of the bench, Nicolet has created a program within the Omnic software called ValQ. This program performs the following checks of the bench:
  - Background
  - 100% line
  - Signal to noise measurement
  - Two internal polystyrene standards to compare specific peak locations over time. These peak locations are only useful for the search function when searching commercially available libraries and have nothing to do with actual peak locations of chemical bonds.
  - A report is generated each time the ValQ is performed and a pass/fail score is given to the instrument in each of these areas. If a “fail” score is given, then something is wrong with the bench and more diagnostics need to be performed or a service technician will have to evaluate the instrument.

FTIR Bench

- Run the ValQ whenever the bench is used or annually, whichever is more frequent. Place a copy of the ValQ report in the FTIR notebook with the analyst’s initials and date.

Continum FTIR Microscope Alignment

- To evaluate the performance of the microscope, the microscope must be aligned properly prior to each use. When aligned properly the signal throughput for the microscope in the %T mode should be between 10 and 15 at a gain of 1 and in %R mode the signal should be between 8 and 10 at a gain of 1. The signal, along with the shapes and locations of the interferogram and the single beam spectra determine if the instrument is aligned and operating properly.
  1. Be sure the microscope is turned on and the detector dewar has been filled with liquid nitrogen.
  2. Select reflection viewing mode by pressing the mode selection switch on the front panel.
  3. Adjust the reflection illumination to medium intensity. Adjust the transmission illumination and Reflex aperture illumination to their lowest intensities. The field irises for transmission and reflection should be fully open and the aperture irises for transmission and reflection should be set for low contrast.
  4. Set the objective and condenser compensation rings to zero.
  5. Place the slide with the pinhole onto the stage and position the pinhole directly under the objective.
  6. Use the X and Y position knobs to center the pinhole on the reticle cross hairs and then refocus to a sharp image.

7. Adjust the Reflex aperture illumination so that the apertured area is brighter than the rest of the field of view.
8. Adjust the size, shape, and orientation of the aperture to match the reticle reference square. If you cannot match the reference square the viewer is out of alignment. A service call should be made to correct this situation.
9. Position the large open hold of the slide directly under the objective.
10. Select transmission viewing mode by pressing the mode selection switch on the front panel.
11. Adjust the transmission illumination to medium intensity.
12. Adjust the condenser focus knob and the condenser centering knobs so that the post-sample aperture image is sharply focused and matches the reticle reference square.
13. Check the signal throughput using the Omnic software. Chose Experiment Setup from the Collect menu. Click on the Bench Tab. Check the following settings:
    a. Gain =1
    b. Sample Compartment = Right µScope. %T
    c. Velocity =1.8988
    d. Detector = MCTA
    e. Beam Splitter = Kbr
    f. Source = IR
    g. Accessory = None
    h. Window Material = none
14. Check the radio button to read Peak to Peak. The interferogram present in the window should look normal and centered in the window. If the microscope is aligned properly the peak-to-peak value should be between 10 and 15. If the signal is lower than 10, the microscope is not properly aligned. Repeat the alignment procedure. If the signal remains below 10 then you should call for technical support.
15. Check the box marked Single Beam. The interferogram changes to a normal background infrared spectra. This should look normal with peaks for CO2 and water and should be centered in the window.
16. If an experiment will be done in the reflectance mode, then check the signalthroughput with the microscope in that mode using the following procedure:
    a. Select reflection viewing mode by pressing the mode selection switch on the front panel.
    b. Position the gold mirror of the sample side directly under the infrared objective.
    c. Use the focus knob to obtain a sharp image of the mirror surface.
    d. Adjust the size, shape, and orientation of the aperture image so that it matches the reticle reference square.
    e. Chose Experiment Setup from the Collect menu.
    f. Set the sample compartment on Right µScope. %R
    g. Be sure the gain and velocity are set at 1 and 1.8988 respectively.
    h. The peak-to-peak signal value should be between 8 and 10. If the signal is less than 8 you may not get a good reflectance spectra.

i. Check the interferogram and single beam spectra to make sure they are normal and centered.

SEM/EDS

- Routine preventative maintenance of the analytical equipment will be provided by the manufacturers.
- Each run will contain a QC test from a known GSR stub (see GSR method) or a known salt stub (see paint method)
    - Results included in the case packets
- If the instrument is taken out of service or maintenance is completed on the instrument, the QC test will be run before the instrument is put back online
- All maintenance records are kept in logbook
- Filament exchange and Wehnelt cap cleaning
    - WARNING: Wehnelt cap is extremely hot after running, do not remove with hands, use appropriate tool to remove from electron gun
    - Filament burnout and length of filament life is recorded in logbook
    - Vent instrument
    - Remove Wehnelt cap from instrument
    - Remove filament from Wehnelt cap
    - Clean Wehnelt cap
        - Sonicate with water or detergent and water
        - Polish with metal polish
        - Sonicate with alcohol
        - Sonicate with acetone
    - Place a new filament into Wehnelt cap
    - Place filament and Wehnelt cap into instrument
    - Pump down the instrument
    - Saturate the filament
    - Run the QC test
        - Results included in case packet

61 1 TRAINING

The unit supervisor coordinates the administration of the training program. The Technical Lead or other casework authorized individuals act as trainers. The trainer is responsible for the completion of the training, including lectures, practicals, and written and competency tests. Training outlines document the training process. Reading lists may be amended with more current references.

A formerly trained or experienced trainee may complete training in a more abbreviated form than what appears on the training outline, but will complete a competency test prior to performing independent casework in a scope of competency.

New trainees, who have not performed casework at the San Diego Police Department Crime Laboratory, will complete the following:

1. General knowledge introduction of forensic science
   a. PowerPoint of forensic science services offered at the SDPD Crime Lab. Tour of the SDPD Crime Laboratory
2. Application of ethical practices in forensic science
   a. Review and acknowledgement of City of San Diego employee code of conduct.

INTRODUCTION

- This training will cover the general analysis portion of trace evidence.
- This training is completed after an analyst is competent in all instrumentation

OBJECTIVES

The trainee must be competent in the following instrumentation:

- Microscopes
  - Stereoscope
  - Polarized light microscope (PLM)
  - Comparison scope
- Fourier Transform Infrared Spectrometer (FT-IR)
  - Bench
  - Microscope
- Gas Chromatograph with Flame Ionization Detector (GC-FID)
- Gas Chromatograph and Mass Spectrometer (GC/MS)
- Scanning Electron Microscope with Energy Dispersive X-ray Spectrometer (SEM/EDS)

The trainee has established competence in the following areas:

- Miscellaneous types of evidence examined
- Methods of Collection and Screening
- Examination and characteristics of materials

PRACTICALS

- Completed only if the analyst requires further exercises to develop skills and knowledge in the area of general analysis.

RECOMMENDED CLASS

- Polarized light microscopy or trace evidence course
  - If not available, the training will occur in house

SUGGESTED READING

- Saferstein, R. 1988. Forensic Science Handbook Volume II, Chapter 4, Englewood Cliffs, NJ: Prentice Hall
- Saferstein, R. 2010. Forensic Science Handbook Volume III, Chapter 1, Englewood Cliffs, NJ: Prentice Hall

COMPETENCY

- The competency will contain a set of unknowns the trainee must examine and properly categorize under mineral, vegetable, animal, or other. If possible, the trainee will further categorize the unknowns within the larger categories (e.g. mineral to glass).
- Trainee must receive 100% with evaluation

INTRODUCTION

- This training will cover the basic concepts of fire chemistry and ignitable liquid detection, and collection.

OBJECTIVES

The trainee should develop knowledge and skills in the following areas:

- Parameters required to start and maintain combustion
- Recognition and categorization of different types of ignitable liquids used to accelerate a fire
- Utilization of different methods for isolating ignitable liquids using laboratory methods including understanding the capabilities and limitations of each method
- Identification and/or comparison of ignitable liquids with a thorough understanding of the instrumental methods used in analysis.
- Flammability testing
- Examination and analysis of case materials with consideration of other types of evidence that may be associated with the samples
- Interpretation of the forensic significance of the analytical results obtained.

TRAINING

The following topics will be covered in fire debris training:

- Fire chemistry
- Fire investigation
- Evidence recognition, collection, packaging, and field investigation
- Petroleum products
- Naturally occurring products
- Ignitable liquid characterization
- Safety considerations
- Ignitable liquid recovery and isolation techniques
- Incendiary devices
- Chromatography
  - GC-FID
  - GC/MS
- Microbial degradation of petroleum products
- Ignition and flammability testing

PRACTICAL EXERCISES

SUGGESTED READING

- CCI Arson Accelerant Detection notebook
- DeHaan, John, 1991. Kirk's Fire Investigation, 3rd Ed., Prentice- Hall, Inc.
- Applicable ASTM methods
- CCI Fire and Explosive Investigation notebook
- Icove, D., and DeHaan, J., 2004. Forensic Fire Scene Reconstruction, Upper Saddle River, NJ: Pearson Prentice Hall.

- O'Connor, J., 1987. Practical Fire and Arson Investigation, New York, Elsevier Science.

FINAL WRITTEN EXAM

- Trainee must receive 80% or better with evaluation

COMPETENCY

- Trainee must receive 100% with evaluation

64 4 TRAINING: DETECTION AND EXAMINATION OF IMPRESSION EVIDENCE

INTRODUCTION

- This training will cover the basic concepts of footwear and tire manufacturing, impression collection techniques, enhancement of impressions techniques, and methods for comparison of impressions.

OBJECTIVES

The trainee should develop knowledge and skills in the following areas:

- Basic concepts of forensic footwear and tire impression evidence
- Basic knowledge of tire and footwear manufacturing
- Impression characteristics and comparable features
- Impression collection techniques
- Impression enhancement techniques
- Comparison and examination procedures

TRAINING

The following topics will be covered in impression evidence training:

- Basic impression terminology
- Different types of impressions
- Value of impression evidence
- Footwear and Tire manufacturing methods
- Collection techniques for impression evidence
- Enhancement techniques for impression evidence
- Class characteristics in footwear and tires
- Wear characteristics in footwear and tires
- Identification characteristics in footwear and tires
- Examination procedures for impression evidence
- Collection of exemplars from known footwear and tires

PRACTICAL EXERCISES

SUGGESTED READING

- Bodziak, William, 2000. Footwear Impression Evidence, 2nd Ed., CRC Press.
- McDonald, Peter, 1993. Tire Imprint Evidence, CRC Press.

FINAL WRITTEN EXAM

- Trainee must receive 80% or better with evaluation

COMPETENCY

- Trainee must receive 100% with evaluation

65 TRAINING: HAIR EXAMINATION

INTRODUCTION

- This training will cover the basic concepts of hair characteristics, microscopy, recovery of evidence, and hair growth.

OBJECTIVES
The trainee will gain knowledge and skills in the following areas:

- Microscopy
- Hair morphology
- Human hair characteristics
- Animal hair characteristics
- Evaluation of hair standards
- Recovery of hair evidence
- Methods for comparison
- Methods for documentation
- Evaluation of the hair root for nuclear DNA analysis
- Evaluation of damage, color treatment, and other conditions to hair
- Laboratory report writing in this area

TRAINING
The following topics will be covered:

- Lectures on hair growth and structures, hair structure, hair comparisons, special topics in comparisons, DNA techniques of hair analysis
- Macroscopic and microscopic characteristics of hairs
- Scale casting
- Somatic origin
- Human vs. animal hair characteristics
- Examination of hair standards
- Comparison of question hair to hair standards
- Hair root documentation and nuclear DNA suitability

PRACTICAL EXERCISES

SUGGESTED READING

- Saferstein, R. 1982. Forensic Science Handbook Volume I, Chapter 5, Englewood Cliffs, NJ: Prentice Hall
- Gaudette, B.D. and Keeping, E.S. "An attempt at determining probabilities in Human Scalp hair comparison". Journal of Forensic Science, 1974, Jul; 19(3): 599-606.

FINAL WRITTEN EXAM

- Trainee must receive 80% or better with evaluation

COMPETENCY

- Trainee must receive 100% with evaluation

INTRODUCTION

- This training will cover the basic concepts of fiber manufacturing, fiber characteristics, microscopy, recovery of evidence, Fourier Transform Infrared Spectroscopy (FT-IR), and thin layer chromatography (TLC).

OBJECTIVES

The trainee will gain knowledge and skills in following areas:

- Fiber and textile manufacturing processes
- Manmade fibers v natural fibers
- Microscopy
  - Stereomicroscope
  - Transmitted light microscopy
  - Polarized light microscopy
- Cross sections
- Solubility
- FT-IR
- TLC

TRAINING

The following topics will be covered:

- Textile manufacturing
- Fiber manufacturing
- Fiber retention on samples
- Fiber type commonality
- Natural fibers
- Microscopy
- Polarized light microscopy
- Refractive Indices
- Birefringence and use of Michel-Levy Color Chart
- Cross-sections
  - Microscopic
  - Manual cutting methods
- FT-IR sample prep
- FT-IR sample run
- Solubility
- TLC for dye analysis
- Comparison methods

PRACTICAL EXERCISES

SUGGESTED READING

- Gaudette, B. The forensic aspects of textile fiber examination. In: Forensic Science Handbook (Vol. 2). Ed., R. Saferstein. Prentice-Hall, Englewood Cliffs, New Jersey, 1988.
- Robertson, J. The forensic examination of fibers: Protocols and approaches—An overview. In: Forensic Examination of Fibers. Ed., J. Robertson. Ellis Horwood,

Chichester, United Kingdom, 1992.

- CCI Fiber Training Manual
- CCI Basic Practical Microscopy Manual
- SWGMAT Fiber training and analysis procedures

FINAL WRITTEN EXAM

- Trainee must receive 80% or better with evaluation

COMPETENCY

- Trainee must receive 100% with evaluation

6.7 TRAINING: PRIMER GUNSHOT RESIDUE (GSR)

INTRODUCTION

- This training will cover the basic concepts primer gunshot residue and the Scanning Electron Microscope with Energy Dispersive X-ray Spectroscopy (SEM/EDS).

OBJECTIVES

The trainee will gain knowledge and skills in the following areas:

- Collection of primer gunshot residue from hands and clothing
- Limitations of collections and analysis
- Reaction when firearm is discharged
- Ammunition components and variations
- Composition and morphology of primer gunshot residue
- Scanning electron microscopy
- Electron dispersive x-ray spectroscopy

TRAINING

The following topics will be covered:

- History of GSR analysis
- Limitations of GSR analysis
- Ammunition and firearm differences and effect on GSR produced
- Gunpowder characteristics, intact v discharged
- Formation of GSR
- Composition of GSR
- Deposition of GSR
- Environmental and occupational materials similar to GSR
- Collection method of GSR
- Definition of a GSR environment
- Duration of GSR on individual hands, clothing, or objects
- SEM/EDS
    - Theory
    - Basic function/method
    - Specific use for GSR
    - Maintenance and troubleshooting

PRACTICAL EXERCISES

SUGGESTED READING

- JEOL and Oxford User Manuals
- Wolten, G. M., Nesbitt, R. S., Calloway, A. R., Loper, G. L., and Jones, P. F. "Final Report On Particle Analysis For Gunshot Residue Detection". Segundo, CA: Aerospace Corporation, 1977.
- Krishnan, S. S. “Detection of Gunshot Residue: Present Status.” Krishnan, S. S. Forensic Science Handbook, Volume 1. Ed. Richard Saferstein. Englewood Cliffs, NJ: Prentice Hall, Inc., 1982. 572-591.

- White, R. S. and Owens, A. D. “Automation of Gunshot Residue Detection and Analysis by Scanning Electron MicroscopyEnergy Dispersive X-Ray Analysis (SEM/EDX).” Journal of Forensic Sciences (1987): 1595-1603.
- Wright, D. M. and Trimpe, M. A. “Summary of the FBI Laboratory's Gunshot Residue Symposium May 31-June 3, 2005.” Forensic Science Communications (2006).
- Romolo, F. S. and Margot, P. “Identification of Gunshot Residue: A Critical Review.” Forensic Science International (2001): 195-211.
- Wrobel, H., Millar, J. J., and Kijek, M. “Identification of Ammunition From Gunshot Residues and Other Cartridge Related Materials--A Preliminary Model Using .22 Caliber Rimfire Ammunition.” Journal of Forensic Sciences (1998): 324-328.
- Wallace, JS. And McQuillan, J. “Discharge Residues from Cartridge-operated industrial Tools.” Journal of the Forensic Science Society 1984; 24: 504.
- Kilty, J. W. “Activity after Shooting and Its Effect on the Retention of Primer Residue.” Journal of Forensic Sciences (1975): 219-230.
- Berk, R. E. “Automated SEM/EDS Analysis of Airbag Residue as a Source of Percussion Primer Residue Particles I and Automated SEM/EDS Analysis of Airbag Residue as a Source of Percussion Primer Residue Particles II.” Journal of Forensic Sciences (2009): 60-68, 69-76.
- Mosher, P. V., McVicar, M. J., Randall, E. D., and Sild, E. H. “Gunshot Residue-Similar Particles Produced by Fireworks.” Canadian Society of Forensic Sciences Journal (1998): 157-168.
- Torre, C., Mattutino, G., Vasino, V., and Robino, C. “Brake Linings: A Source of Non-GSR Particles Containing Lead, Barium and Antimony.” Journal of Forensic Sciences (2002): 494-504.

FINAL WRITTEN EXAM

- Trainee must receive 80% or better with evaluation

COMPETENCY

- Trainee must receive 100% with evaluation

68 TRAINING: PHYSICAL MATCH

INTRODUCTION

- This training will cover the basic concepts of physical matches with commonly encountered evidence.

OBJECTIVES

The trainee will gain knowledge and skills in the following areas:

- General properties from a variety of separated materials
- Discrimination of physical compositional features of separated materials including relevant manufacturing characteristics
- Influence of distortion and forces that cause distortion on different materials
- Types of separation forces
- Photography

TRAINING

The following topics will be covered:

- Comparing and contrasting visible properties of separated materials
- Manufacturing characteristics of materials commonly observed
- Physical characteristics of materials commonly observed
- Distortion of materials
- Forces that cause distortions
- Effect of the type of force of separation on material and match analysis
- Processing of evidence for physical match, such as undoing a wad of tape
- Photography, alternate light sources, and documentation

PRACTICAL EXERCISES

SUGGESTED READING

- ASTM Standard E2288, 2003, "Standard Guide for Physical Match of Paper Cuts, Tears, and Perforations in Forensic Document Examinations." ASTM International, West Conshohocken, PA, 2003.
- Saferstein, R., ed. *The Forensic Science Handbook, Volume I, 2nd Edition.* New Jersey: Pearson Education, Inc., 2002. Chapter 4: Forensic Glass Comparisons.
- Bradley, M.J., et al. "A Validation Study for Duct Tape End Matches."
- *Journal of Forensic Sciences* 51.3 (2006): 504-508.
- Dixon, K. "Positive Identification of Torn Burned Matches with Emphasis on Cross Cut and Torn Fiber Comparisons." *American Academy of Questioned Document Forensic Scientists* (August 1982).
- Laux, D. "Identification of a Rope by Means of a Physical Match Between the Cut Ends." *Journal of Forensic Sciences* 29.4 (1984): 1246-1248.
- VonBremen, U.G. and B. Lorne. "Physical Comparison of Plastic Garbage Bags and Sandwich Bags." *Journal of Forensic Sciences* 28.3 (1983).

FINAL WRITTEN EXAM

- Trainee must receive 80% or better with evaluation

COMPETENCY

- Trainee must receive 100% with evaluation

69 TRAINING: PAINT

INTRODUCTION
- This training will cover the basic concepts of paint manufacturing, paint characteristics and layers, and paint examinations.

OBJECTIVES
The trainee will gain knowledge and skills in the following areas:
- History of paint
- Paint manufacturing processes
- Search and collection techniques
- Microscopical examinations and characterization
- Binder Classification
- Pigment Identification
- Extender Examination
- Additive Examinations
- After-market treatments, weathering, aging, and contaminants
- Significance and interpretation of paint analysis and comparison

TRAINING
The following topics will be covered:
- History of paint
- General and Forensic terminology
- Uses and composition of paint
- Manufacturing processes
- Collection techniques
- Microscopical examination and characterization
- Sample preparation techniques
- Solvent examinations
- Microchemical examinations
- Infrared spectroscopy for binder identification, pigments, and extenders
- SEM/EDS
  - Theory
  - Basic function/method
  - Use for identification of inorganic particles and residues
  - Maintenance and troubleshooting
- SEM/EDS for pigment and extender examination
- Additive types, functions, and methods of analysis
- Classification of paint
- Comparison and discriminations of paint

PRACTICALS

SUGGESTED READING

- Thornton, J.I., "Forensic Paint Examination, Forensic Science Handbook", 1982, pp 529 – 571.
- "Paint Examination and Comparison Reference Notebook", CCI, 1999. "Paint Examination and Comparison Class Workbook", CCI, 1999.
- McCrone, Walter C. and Delly, John G., "The Particle Atlas, vol. 2", Ann

- Arbor Science Publishers, Ann Arbor, Michigan: 1973.
- Crown, David A., "Forensic Examination of Paints and Pigments", Charles C. Thomas Publishing, Springfield, IL: 1968.
- Tillman, Warren L., "Automotive Paint Systems Identification", Proceedings of the International Symposium on the Forensic Aspects of Trace Evidence, FBI, June 1991, pp 123-152.

FINAL WRITTEN EXAM

- Trainee must receive 80% or better with evaluation

COMPETENCY

- Trainee must receive 100% with evaluation

INTRODUCTION

- This training will cover the basic concepts of legal issues, testimony, court systems, and court presentations. This training module is provided to new Criminalists in the Trace evidence unit. A criminalist who has prior Trace Evidence testimony experience will not be required to complete this training module.

OBJECTIVES

The trainee will gain knowledge and skills in the following areas:

- Understand the Federal Rules of Evidence (FRE)
- Understand the Frye Standard, *Frye v. US* 1923.
- Understand the impact of *Daubert v. Merrell Dow Pharmaceuticals* 1993, *General Electric Co. v. Joiner* 1997, and *Khumo Tire v. Carmichael* 1999 on expert testimony.
- Learn the different court systems in which laboratory employees can testify to (superior, federal, civil).
- Understand the basis of criticisms of Trace Evidence examinations.
- Understand how discovery motions, court orders, and outside experts are handled by the SDPD Crime Laboratory.
- Courtroom etiquette
- Courtroom appearance and attire
- Understand voir dire
- Learn how to present qualifications, present the basis and method of examination, introduce evidence, present conclusions, and articulate the basis for conclusions.
- Be able to articulate laboratory accreditation standards and quality assurance policies and procedures.
- Be able to articulate Trace unit and Quality Manual policies and procedures.

LECTURES

- PREPARATION FOR COURT TESTIMONY
    - Jury's perception
    - Research current issues (Daubert, NAS report, PCAST, error rates)
    - Oral preparation prior to court (pre-trial conference)
- PREPARING COURT EXHIBITS
    - Purpose
    - Creating a PowerPoint
- PREPARE QUESTIONS AND ANSWERS FOR EXPERT TESTIMONY
    - Voir dire
    - Basic scientific principles
    - Defense questions
- DISCUSS AND DEMONSTRATE EXPERT WITNESS TESTIMONY

- Court room etiquette
- Communication with prosecutors and defense attorneys
- Audio/video recording of testimony
- Discuss and review testimony

SUGGESTED READING

- Vanderkolk, CH. 1 Objectivity-Subjectivity.
- National Academy of Sciences. Strengthening Forensic Science in the United States: A Path Forward. National Academies Press 2009.

PREPARATION FOR MOOT COURT

MOOT COURT

- Based on a Competency Test
- Court testimony evaluation form used to offer critique of testimony skills and effectiveness