

ARKANSAS STATE CRIME LABORATORY

Trace Evidence Unit Quality Manual

1.0	Introduction (Goals and Objectives)	4
1.1	<i>Organization and Management Structure</i>	4
2.0	Personnel Qualifications And Job Descriptions	5
2.1	<i>Job Descriptions</i>	5
2.2	<i>Educational Requirements</i>	7
2.3	<i>Special Training Requirements</i>	8
3.0	Facilities/Security	10
3.1	<i>Arkansas State Crime Laboratory</i>	10
3.2	<i>Trace Evidence Unit</i>	10
4.0	Evidence Control	11
4.1	<i>Secure Storage</i>	11
4.2	<i>Evidence Handling</i>	11
4.3	<i>Documentation of Evidence and Packaging</i>	12
4.4	<i>Release of Evidence</i>	12
4.5	<i>Disposition</i>	12
4.6	<i>Purging</i>	12
4.7	<i>Destruction</i>	12
4.8	<i>Evidence Assessment</i>	13
4.9	<i>Trace Evidence Policy Statements</i>	13
5.0	VALIDATION	14
6.0	Analytical Procedures (Sop)	15
6.1	<i>Glass Analysis</i>	15
6.2	<i>Gunshot Residue</i>	20
6.3	<i>Identification of Ignitable Liquids</i>	25
6.4	<i>Lamp Filament Examination</i>	32
6.5	<i>Paint Analysis</i>	37
6.6	<i>Collection of Hairs and Fibers</i>	40
6.7	<i>Macro/Microscopic Hair Examination</i>	43
6.8	<i>Fiber Analysis</i>	47
6.9	<i>Physical (Fracture) Matches</i>	51
6.10	<i>Indented Writing</i>	53
6.11	<i>Miscellaneous Evidence Types</i>	56
7.0	INSTRUMENT MAINTENANCE AND QUALITY CONTROL	58
7.1	<i>Scanning Electron Microscope</i>	58
7.2	<i>Microscopes (Stereo-, Comparison, Polarizing Light)</i>	59

7.3	<i>Fourier-Transform Infrared Spectrometer</i>	60
7.4	<i>Glass Refractive Index Measurement System 2</i>	62
7.5	<i>Microspectrophotometer</i>	63
7.6	<i>Gas Chromatograph-Mass Spectrometer</i>	65
7.7	<i>Chemicals and Reagents</i>	67
8.0	Proficiency Testing Program	68
9.0	Case Records	69
9.1	<i>Documentation</i>	69
9.2	<i>Release of Information</i>	69
9.3	<i>Technical and Administrative Reviews</i>	69
10.0	Testimony Review	70
11.0	Audits	70
12.0	Complaints	70
13.0	Safety	70

TRACE EVIDENCE

1.0 INTRODUCTION (GOALS AND OBJECTIVES)

The Trace Evidence Unit is dedicated to providing forensic analysis of physical evidence to the criminal justice system. To this end, we analyze hairs, fibers, paint, glass, ignitable liquids, gunshot residue, fracture matches, lamp filaments, and other materials as required. This analysis is performed in a chain-of-custody environment using proper and appropriate procedures in order to ensure the most accurate and relevant analytical results.

1.1 Organization and Management Structure

1.1.1 *Organization*

The Trace Evidence Unit is part of the Physical Evidence Section. The Physical Evidence Section has a supervisor and is under the supervision of the Scientific Operations Director.

1.1.2 *Management*

This manual has been approved by the Section Supervisor, Scientific Operations Director, and Executive Director and as such is accepted as the routine operating policy of the Trace Evidence Unit within the Arkansas State Crime Laboratory. To discuss possible revisions, meetings between the Section Supervisor and the analysts will be held as needed. Any changes to this manual must be approved through formal chain of command processes, with affected manual pages and files updated. Previous versions of revised documents are maintained in a separate Historical Archive Manual. All analysts must be notified of the changes and must be given necessary training.

2.0 PERSONNEL QUALIFICATIONS AND JOB DESCRIPTIONS

2.1 Job Descriptions

2.1.1 *Chief Criminalist*

EXAMPLES OF WORK

- A. Supervises a medium-sized professional staff of Trace Evidence Analysts and Evidence Collection Examiners by interviewing and recommending for hire; training or providing training opportunities; assigning and reviewing work and evaluating the performance of incumbents.
- B. Coordinates section activities by reviewing, prioritizing and assigning new cases; providing assistance to staff in regard to appropriate testing methods and findings; and reviewing selected final reports.
- C. Reviews investigator's summary sheet to become familiar with the details of the crime and examines items such as gunshot residue, fire debris, hair, fiber, paint, glass and soils submitted as potential evidence to determine appropriate testing methods.
- D. Designs and conducts a series of analytical tests (including chemistry, chromatography, mass spectrometry; and transmitted light, stereo and electron microscopy) to try to determine physical and chemical properties of evidence items and identity of evidence items.
- E. Prepares reports of findings and conclusions for submission to legal authorities and courts of law.
- F. Testifies in court as an expert witness on the analysis of evidence and conclusions reached.
- G. Writes articles, presents training and provides consultation to law enforcement officers, prosecutors, defense attorneys and other public officials on crime scene investigation; methods of collecting, transporting and preserving evidence to ensure its integrity and maintenance of the chain of custody.
- H. Researches scientific literature and exchanges information with peers in other states in order to stay abreast of the latest scientific advances in the analysis of criminal evidence and/or determine the best method of testing a particular piece of evidence.
- I. Performs administrative duties by preparing activity reports, inventory reports; maintaining employee history information and equipment maintenance logs; requisitioning supplies and equipment; and researching and recommending policies/procedures.
- J. Conducts on-site crime scene investigations
- K. Performs related responsibilities as required or assigned.

WORKING RELATIONSHIPS

The Crime Laboratory Chief Criminalist has regular contact with other laboratory sections, law enforcement officials, attorneys, criminal/civil court personnel, and peers in other states.

SPECIAL JOB DIMENSIONS

The employee will experience frequent exposure to hazardous, toxic, repulsive and/or infectious materials. Occasional in or out-of-state travel and on-call duty are required.

KNOWLEDGE, ABILITIES AND SKILLS

- A. Knowledge of the principles and practices of chemistry, chemical analysis, and forensic analytical methods and techniques.
- B. Knowledge of laws, regulations and agency policies governing trace evidence analysis.
- C. Knowledge of laboratory equipment.
- D. Ability to plan, organize and oversee the work of subordinates.
- E. Ability to conduct and direct the activities of a trace evidence section.
- F. Ability to write descriptive results of analysis and appear as expert witness in court.
- G. Ability to conduct research, prepare and present training on methods of collecting and preserving evidence.

2.1.2 *Forensic Criminalists*

EXAMPLES OF WORK

- A. Reviews investigator's summary sheet to become familiar with the details of the crime and examines items of evidence to determine appropriate testing methods.
- B. Designs and conducts a series of analytical tests (including chemistry, chromatography, mass spectrography, and transmitted light, stereo, and electron microscopy) to determine the physical and chemical properties of evidence items and identity of evidence items.
- C. Prepares reports of findings and conclusions for submission to legal authorities and courts of law.
- D. Testifies in court as an expert witness on the analysis of evidence and conclusions reached.
- E. Writes articles, presents training and provides consultation to law enforcement officers, prosecutors, defense attorneys and other public officials on crime scene investigation; methods of collecting, transporting and preserving evidence to ensure its integrity and maintenance of the chain of custody.

F. Researches scientific literature and exchanges information with peers in other states in order to stay abreast of the latest scientific advances in the analysis of criminal evidence and/or determine the best method of testing a particular piece of evidence.

G. Conducts on-site crime scene investigations at the request of law enforcement agencies after gaining approval from the Executive Director or the Scientific Operations Director.

H. Performs related responsibilities as required or assigned.

WORKING RELATIONSHIPS

The Forensic Criminalist has regular contact with other laboratory sections, law enforcement officials, attorneys and peers in other states.

SPECIAL JOB DIMENSIONS

The employee will experience frequent exposure to hazardous, toxic, repulsive, and/or infectious materials. Occasional in or out-of-state travel and on-call duty are required.

KNOWLEDGE, ABILITIES AND SKILLS

A. Knowledge of the principles and practices of chemistry, chemical analysis and forensic analytical methods and techniques.

B. Knowledge of laws, regulations and agency policies governing trace evidence analysis.

C. Knowledge of laboratory equipment.

D. Ability to assign and coordinate work activities and monitor the performance of co-workers and/or subordinates.

E. Ability to conduct forensic analysis of criminal evidence.

F. Ability to write descriptive results of analysis and appear as expert witness in court.

G. Ability to conduct research, prepare and present training on methods of collecting and preserving evidence.

2.2 Educational Requirements

2.2.1 *Crime Laboratory Chief Criminalist*

The position requires the formal education equivalent of a bachelor's degree in chemistry or closely related field; plus two years experience in a forensic laboratory. Other job related education and/or experience may be substituted for all or part of these basic requirements upon approval of the Scientific Operations Director.

2.2.2 *Forensic Criminalist*

The position requires the formal education equivalent of a bachelor's degree in chemistry. Other job related education and/or experience may be substituted for all or part of these basic requirements upon approval of the Scientific Operations Director.

2.3 Special Training Requirements

Knowledge of principles and practices of chemistry, chemical analysis, forensic analytical methods and techniques are required to perform the job duties of a Criminalist.

2.3.1 *Training Prior to Casework*

The analyst must demonstrate the ability to perform specific tests properly before performing independent casework. This is ensured by requiring the analyst to undergo in-house training that must include:

- A. Working with a court-qualified analyst in the specific area of analysis to be tested. Each sub-discipline will have specific training requirements (see section 6.0). The duration of this training is dependent upon the type of analysis. The hours of training will be logged by the trainee and reported to the supervisor. At the completion of this course, the training analyst or supervisor will determine if additional training is needed.
- B. Reading and signing off on assigned literature pertaining to the subject matter. This material is assigned by the training analyst or the supervisor.
- C. Passing a written proficiency examination.
- D. Passing an analytical proficiency test given in the area of analysis to be tested.
- E. Participating in at least one moot court.

2.3.2 *Continuing Education*

2.3.2.1 Current Literature

Analysts must read peer-reviewed scientific journals as needed. Analysts must be prepared to share pertinent information at staff meetings. Articles may be assigned by the supervisor and analysts may be asked to locate articles.

2.3.2.2 Training Sessions

Each analyst will take part in at least one training session every year. This may include structured in-house training in a scientific discipline to which the analyst is assigned or is being trained. In addition, each employee may participate in the Arkansas Inter-Agency Training Program.

2.3.2.3 Documentation of Training

Each analyst will be supplied with a binder. All training certificates, college transcripts, proficiency test results, and reviews of testimony will be kept in the binder. It is the responsibility of the individual analyst to keep the binder up to date.

2.3.2.4 Meetings

Section meetings will be held once a month or as often as deemed necessary by the supervisor.

3.0 FACILITIES/SECURITY

3.1 Arkansas State Crime Laboratory

The Laboratory facilities and security are described in the laboratory Quality Manual (Section 3).

3.2 Trace Evidence Unit

The Trace Evidence Unit is secured by lockable doors. The scrape down rooms are also secured by lockable doors. Each analyst has a set of lockable drawers and cabinets. Keys are issued only to the analyst and to the section supervisor. Keys are also kept in the master key box; the Quality Assurance Manager and the Executive Director have a key to the master key box. A section key box is located in the library/break room. The section supervisor maintains the key to the section key box.

4.0 EVIDENCE CONTROL

General guidelines regarding evidence may be found in the laboratory Quality Manual (Section 4).

4.1 Secure Storage

4.1.1 Temporary storage within the section

While in the possession of an analyst, evidence must be controlled at all times. This requires that the evidence be observed or secured. If the analyst is to leave the evidence for an extended period of time, it must be stored in a secure area. A secure area must have access limited to those specifically designated by the administration. Access to the Trace Evidence Unit is only through locked doors. In addition, analysts are provided with individual locked cabinets for storage.

4.1.2 Long-term storage within the section

Evidence removed from larger items (i.e. tape lifts, debris, glass, etc.) is stored in locked evidence cabinets labeled "TR Secure Storage". These items are retained until requested by the agency. As storage space becomes limited, the oldest evidence is returned to the agency.

4.2 Evidence Handling

All evidence must be handled in a manner that preserves the integrity and usefulness of the evidence as much as possible. This is discussed more specifically in the sections of the quality manual dealing with the different analytical procedures.

In general, the original condition of the evidence should be maintained as much as possible while performing all necessary analyses. Nondestructive techniques are preferred over destructive techniques, given that the results obtained through each method of analysis are equally valid and useful. Where modification of the evidence is necessary, all modifications performed by the analyst should be noted in the case file. If such modifications are an integral part of a standard method of analysis, a notation of the method of analysis used will suffice.

Any substance (hairs, fibers, tape lifts, glass, particles, paint layers, etc.) removed from any item of evidence and retained by the Trace Evidence Unit shall be treated as evidence and must be given a barcode. Photographs are generally considered documentation and will not be treated as evidence.

4.3 Documentation of Evidence and Packaging

If handwritten notes are written they should include:

- The case number assigned by the evidence receiving section.
- The evidence number for each piece of evidence submitted for analysis.
- A detailed description of all layers of packaging, noting all seals and any identifying marks.
- A description of the contents of each item of evidence.
- Any comments by the analyst concerning the packaging or condition of the evidence or of any variation from routine procedure.

If notes are documented through Justice Trax, evidence must be itemized with description of packaging and item(s).

4.4 Release of Evidence

The release of evidence is set forth by the laboratory Quality Manual (Section 4.9).

Upon completion of the analysis by the Trace Evidence Unit, items of evidence may be transferred to the Evidence Receiving Section, to another analyst or may be retained.

Occasionally evidence needs to be sent to another laboratory for analysis. The Trace Evidence Criminalist will complete an Inter-Laboratory Evidence Transfer Form (ASCL-FORM-07).

4.5 Disposition

Hair slides, tape lifts and other items necessary to retain will be stored in the cabinets designated for storage.

4.6 Purging

Old paper case files are stored in the Trace Evidence Unit or in other areas designated for file storage. These files will be scanned into Justice Trax and then purged.

Every three years or as space restrictions demand, retained evidence will be returned to the investigating agency.

4.7 Destruction

The Trace Evidence Unit does not destroy any evidence. All evidence is returned to the respective law enforcement agency.

Case information from Justice Trax may be printed for court purposes. Upon returning from court the documentation may be destroyed.

4.8 Evidence Assessment

4.1.3 Evidence Assessment by Supervisor

The supervisor or his/her designee will evaluate each case to determine:

- what the law enforcement officer wants/needs with regards to each item of evidence.
- if the ASCL is equipped to perform the requested analysis. If not, the supervisor will assist the officer in location of a laboratory that performs said analysis.
- which analyst(s) will be assigned to the case.

The above may require a conversation with the officer for clarification of the analysis needed. The supervisor may require the assigned analyst to make the assessment and plan a course of action.

4.1.4 Evidence Assessment by analyst

Each sub-discipline will have specific assessment requirements. These are to be performed by the analyst assigned to the case.

- Discrepancies between the submitting agency's description of the evidence and the analyst's observations must be resolved prior to analysis/the completion of the report.

4.9 Trace Evidence Policy Statements

The Trace Evidence Unit will not examine gunshot residue kits or clothing from individuals who have sustained an injury from the discharge of a firearm. Gunshot residue may be obtained from touching the wound or a surface bearing gunshot residue or being in close proximity to a firearm at the time of discharge.

Guns hot residue kits should not be collected from anyone in possession of a firearm. These kits will not be examined by the Trace Evidence Unit due to the fact that gunshot residue may be obtained by handling a firearm. Clothing from suspects in possession of a firearm will not be examined for primer gunshot residue.

The Trace Evidence Unit will not analyze hairs and fibers on items belonging to individuals who co-habitat or have legitimate reasons to have transfer of hairs and fibers.

The Trace Evidence Unit does not routinely examine clothing items for knife cuts. The documentation of cuts on the clothing is insignificant compared to the information provided by the Medical Examiner's examination of the wounds to the body.

The presence of hairs or fibers on the end of the muzzle of a firearm cannot be used in distance determination. The presence of hairs or fibers also cannot be used as an indicator of a self-inflicted wound as opposed to homicide.

The Trace Evidence Unit reserves the right to not analyze any evidence that is not properly packaged.

5.0 VALIDATION

The Trace Evidence Unit uses procedures that are well established and generally accepted in the field of chemical analysis. In Section 6 of this manual, references are provided to document that the techniques used are based on widely established scientific principles.

Validation is conducted in accordance with the laboratory Quality Manual (Section 5).

After a new procedure has been validated, it should be incorporated into the Trace Evidence Quality Manual.

COPY

6.0 ANALYTICAL PROCEDURES (SOP)

6.1 Glass Analysis

6.1.1 Training

- Training will be conducted by a qualified glass analyst.
- Completion of proficiency and written test(s)
- Moot court, if necessary

6.1.2 Evidence Assessment by Analyst

- Determine which items are known samples and which items are questioned samples.
- Review submission information to determine which other sections will be analyzing evidence. Caution should be used to preserve evidence to be sampled by other sections.

6.1.3 Preparation and Sampling Techniques

6.1.3.1 Recovery of Glass from Clothing and Objects

- Visually examine the item for glass.
- Remove any visible glass fragments with forceps or probes.
- Hang clothing items to be examined on a rod over a clean white sheet of butcher paper. Small items may be held over the paper.
- Use a spatula to tap the item and then scrape it. Probes may be used for smaller objects with indentions.
- Collect the debris in an appropriate container.
- Examine the debris under the stereomicroscope.
- Remove any glass fragments with forceps and place in folded paper or a suitable container.

6.1.3.2 Collection of Known Glass Samples

- Check known sample submitted to determine if there is any difference within the sample.
- If a large sheet of glass is submitted, collect a representative glass sample. If it appears that differences may exist within the glass, samples may be collected from several areas.

6.1.4 Testing Techniques

6.1.4.1 Physical Properties

- If attempting to determine if a particle is glass, it may be necessary to examine the particle under crossed-polarized light using a polarizing light microscope. Particles that exhibit complete extinction during 360 degrees of rotation are isotropic and indicative of glass. Anisotropic particles are eliminated as being glass.
- Record visual observations regarding the known and questioned glass samples such as color, surface texture, curvature or markings.
- Determine type of glass, if possible. Types include flat, plate, container, tempered, non-tempered, mirrored, reinforced, laminated, light bulb or tube, headlight, and decorative glasses.
- Check for a physical fit if adequate known and questioned samples are submitted. Fracture match determinations should be performed in accordance with Fracture Match protocols (Sec. 6.9).
- Examine samples under short and long wavelength UV light and record any fluorescence.
- Measure the thickness if two original surfaces exist in both glass samples. Using a micrometer, record the value to 1/100 of a millimeter. Take measurements from several areas of the known sample to determine a range of thickness.

6.1.4.2 Optical Properties

- Large pieces of glass should be broken to create small fragments for mounting. If possible, use non UV fluorescent surfaces.
- Select an appropriate silicone oil and mount the crushed glass on a hot stage slide. Some particles may require further crushing within the oil. Cover with a cover slip.
- Place the slide in the hot stage on the phase contrast microscope. Allow the slide to come to the temperature of the hot stage and focus on the image.
- Place the square on an edge of glass showing a high contrast.
- Change the temperature of the hot stage until the glass disappears. Note the temperature and begin the analysis using a temperature a few degrees higher than the disappearance temperature.
- Measure the refractive index using the Glass Refractive Index Measurement System (GRIM2). The GRIM system is set in accordance with manufacturer's instructions to vary the temperature within the hot stage and determine the point of minimum contrast along an edge of glass. The temperature at which the glass disappears is recorded during a heating and cooling cycle and the match point temperature is established. The system will display and print the refractive index of the glass based upon the match point temperature and the calibration curve established for the immersion oil.
- Refractive indices for the questioned and known should be determined using the sodium D filter. In addition, C and F filters may be used.
- Measure at least 5 fragments of the reference standard, at least 10 of the known (control) glass, and 5 to 10 of the questioned (recovered) glass, if possible.
- If only a small amount of questioned sample is available for testing, the glass should be demounted and retained.

6.1.4.3 Elemental Analysis

- Place small fragment of glass on the carbon adhesive tape of a Scanning Electron Microscope (SEM) stub.
- Load the stub in the SEM chamber and vent the chamber for analysis.
- Turn the filament on and saturate.
- Perform a calibration of the standard and quant calibrate from the data analysis screen.
- Collect spectra and determine if there is a similar elemental composition between the questioned and known samples.

6.1.4.4 Glass Fibers

- Examine clothing items or objects and recover any foreign glass fibers using procedures described in section 6.1.3.1.
- Compare the physical properties of known and questioned glass fiber samples. The color of resin, UV fluorescence, presence of slugs, and other outstanding characteristics should be recorded.
- Mount a sample of the fibers in a suitable mounting liquid for microscopic examination. Determine the diameter range of the fibers using a calibrated reticule.
- Place a portion of the questioned and known samples in separate porcelain crucibles and place in muffle furnace. Anneal by heating to approximately 550 degrees C and slowly cool.
- Test the solubility of a portion of the annealed fibers using concentrated HCl. Glass wool is insoluble, rock wool is soluble, and slag wool is partially soluble. (If no resin is present on the non-annealed sample, this step may be done prior to the annealing procedure.)
- Compare the optical properties of the known and questioned annealed samples using the procedures described in section 6.1.4.2.

6.1.5 Validation

- “Trace Evidence Recovery Guidelines”, Technical Working Group on Materials Analysis, Evidence Handling Committee, FBI, January 1998.
- ASTM, E1967-98, Standard Test Method for the Automated Determination of Refractive Index of Glass Samples Using the Oil Immersion Method and a Phase Contrast Microscope.

6.1.6 Quality Assurance/Quality Control

- Examination area should be cleaned and paper changed between known and questioned items.
- Change gloves and lab coat between examining questioned and known items.
- Clean tools between use on questioned and known samples or use two sets of tools.
- Glass particles recovered from debris may need to be cleaned prior to analysis.
- A representative sample should be chosen from the known source to include the variations that may be seen within a glass sample.
- Record data in the logbooks.

- If samples are to be annealed, known and questioned samples should be annealed simultaneously to insure the samples are subjected to identical conditions.
- A safety shield or glasses which provide protection from UV light should be used when examining samples under UV lighting.
- Tongs and insulated gloves should be used when working with a muffle furnace at high temperatures.

6.1.7 Notes/Documentation

- Evidence and packaging should be documented in accordance with section 4.3 of this manual.
- Glass Analysis Worksheet
- Refractive index data from GRIM2
- Elemental analysis data from SEM

6.1.8 Assessment of Results

6.1.8.1 Review of Data

- If physical characteristics are dissimilar, no additional analysis needs to be performed. If only a small fragment is recovered, additional analysis may be necessary.
- The refractive index for the questioned sample should fall within the refractive index range of the known sample.
- Elemental composition should be the same for known and questioned samples to be considered similar.

6.1.8.2 Reporting Suggestions

- Consistent samples: The glass in item () was optically and elementally consistent with the glass in the known sample ().
- Inconsistent samples: The glass in item () was physically, optically and/or elementally dissimilar to the glass in the known sample ().
- Inconclusive: It could not be determined if the glass in item () was consistent with the glass in item (). The examination is inconclusive.
- Disclaimer: It is noted that glass cannot be positively identified as having originated from a particular source to the exclusion of all other similar sources.

6.1.9 Bibliography

6.1.9.1 References for Recovery of Glass

- Miller, Elmer T., "Forensic Glass Comparison," Forensic Science Handbook, Prentice-Hall, Inc., 1982, pp. 139-183.
- Harrison, P. H., Lambert, J. A., and Zoro, J. A., "A Survey of Glass Fragments Recovered from Clothing of Persons Suspected of Involvement in Crime," *Forensic Science International*, 1985, Vol. 22, pp. 171-187.
- Brewster, F; Thorpe, J.; Gettinby, G.; Caddy, B.; "The Retention of Glass Particles on Woven Fabrics", *Journal of Forensic Sciences*, Vol. 30, No. 3, 1985, pp. 798-805.

6.1.9.2 References for Physical Properties

- Miller, Elmer T., Forensic Glass Comparison." Forensic Science Handbook, Prentice-Hall, Inc., 1982, pp. 139-183.
- Bird, M. A., "Glass for the Bottle Buff", *Gems and Minerals*, Aug. 1971, pp. 28-30.

6.1.9.3 References for Optical Properties

- Ryland, S. G., "Sheet or Container?—Forensic Glass Comparison with an Emphasis on Source Classification", *Journal of Forensic Sciences*, Vol. 31, No. 4, Oct. 1986, pp. 1314-1329.

6.1.9.4 References for Elemental Analysis

- Hickman, D. A., "Linking the Criminals to the Scene of the Crime with Glass Analysis," *Analytical Chemistry*, Vol. 56, No. 7, 1984, pp. 844A-852A.
- Ryland, S. G., "Sheet or Container?--Forensic Glass Comparisons with an Emphasis on Source Classification", *Journal of Forensic Sciences*, Vol. 31, No. 4, Oct. 1986, pp. 1314-1329.

6.1.9.5 References for Glass Fibers

- Miller E. T., "A Practical Method for the Comparison of Mineral Wool Insulations in the Forensic Laboratory," *Journal of the Association of Official Analytical Chemists*, 1975, V 58 (5), pp. 865-870.
- Hopen, T., Brown, R., and Millette, J., "Light and Electron Microscopy of Glass Fibers," unpublished paper, MVA, Inc.

6.1.9.6 Reference Collections

- "Locke Scientific Reference Glass Standards", Locke Scientific.
- "Index of Refraction Standards", Set No. M-1, Control 0659, R. P, Cargille Laboratories, Inc.
- Glass database collected by the Arkansas State Crime Laboratory.

6.2 Gunshot Residue

6.2.1 Training

In addition to the general guidelines for training listed previously in this manual, the analyst training in gunshot residue must complete the following tasks before he/she can be assigned independent casework:

- Complete the required reading relating to gunshot residue analysis
- Have an understanding of current firearms and ammunition
- Be proficient in the use of a Scanning Electron Microscope
- Interpret data from hand stubs and clothing analysis
- Pass a written exam and a proficiency test
- Moot court, if necessary

6.2.2 Evidence Assessment by Analyst

- Kits and clothing collected from gunshot wound victims will not be tested.
- Clothing items must be packaged in a way that allows for adequate drying. Items contained in plastic bags can mold and deteriorate compromising the integrity of the evidence.
- Shoes and undergarments may not be tested.
- Collection kits must have the information sheet completed correctly.
- Kits collected more than 6 hours after the time of the shooting will not be tested.
- Kits or clothing collected from individuals with a firearm in their possession will not be tested.
- Kits or clothing collected from individuals admitting to firing a weapon will not be tested.

6.2.3 Preparation and Sampling Techniques

6.2.3.1 Suspect clothing

- Place the item to be examined on a clean white sheet of paper.
- Press carbon-coated adhesive stub on area to be tested.
- Label stub.

6.2.3.2 Gunshot Residue Kits

- Open gunshot residue kits one at a time.
- Inspect gunshot residue kits for the type used. Record this information in notes.
- Label each plastic stub holder. Label the stub or record the unique ID number.
- Record name of person sampled from information sheet. Scan this information sheet into the case file.

6.2.4 Testing Techniques

6.2.4.1 Minimum Testing

- Suspect clothing and collection kits must be examined for the presence of elements used in firearm ammunition primer.
- Test entire stub or until sufficient number of particles are found.
- If a kit is positive, the clothing from that individual will not be tested.
- If an item of clothing is found to be positive, remaining clothing items will not be tested.

6.2.4.2 Gunshot Residue Kits and SEM stubs

- Place stubs in the sample holder of the SEM.
- Close sample compartment and obtain a vacuum.
- Optimize the SEM conditions for Energy Dispersive X-ray Spectrometry (EDS) collection.
- Enter case information in the EDS system.
- Use the cobalt and rhodium standard stub to set the calibration levels of the backscatter detector.
- Include control stub. This is usually sampled from a firearms analyst immediately after test firing a firearm. Test threshold level on known area of stub.
- Start automated gunshot analysis.
- Confirm particles.
- Include instrument results in case information.

6.2.5 Validation

- ASTM E1588-07 Standard Guide for Gunshot Residue Analysis by Scanning Electron Microscopy/Energy Dispersive X-ray Spectrometry

6.2.6 QA/QC

6.2.6.1 Clothing Items

- Items of clothing should be opened one at a time and labeled.
- All items should be examined on a clean sheet of white butcher paper.
- All bench areas should be cleaned between each different case.
- If hair and fiber analysis is to be conducted also, tape lifts should be collected after SEM stubs are collected.
- Blank: a blank stub should be run with each batch of stubs.

6.2.6.2 Gunshot Residue Kits:

SEM/EDS instrument:

- Control Sample: an area on the control stub will be analyzed prior to every run to ensure proper setup.
- Logbook: date, operator, resolution, and maintenance will be included in the logbook.
- Blank: a blank stub should be run with each batch of stubs.
- Each stub should be marked so that it can be returned to the same position in the holder if removed.

6.2.7 Notes/ Documentation

6.2.7.1 Description of packaging

Refer to section 4.3 of this manual for general guidelines for package description.

6.2.7.2 Suspect Clothing

- Detailed description of the item
- Description of areas where stubs were collected.

6.2.7.3 Gunshot Residue Kits

Worksheets will be provided that include spaces for information that include:

- Packaging of evidence.
- Brand or type of collection kit.
- Number of collection stubs.
- Name of person sampled from information sheet.
- Results of SEM/EDS analysis.

6.2.8 Assessment of Results

6.2.8.1 Gunshot Residue Kits and SEM stubs

Various particle combinations may be identified during the course of the automated gunshot program. Possible particle combinations and their designations are:

- Pb, Sb, Ba – characteristic
- Pb, Sb – indicative
- Pb, Ba – indicative
- Sb, Ba – indicative

Note: other possible element combinations such as Sn, Pb environmental, Cu, and Zn may be included in the indicative category.

Particles identified by the instrument need to be confirmed for use in declaring a result of gunshot residue presence.

Possible conclusions which may be determined from the result of the analysis are:

- Particles characteristic of gunshot residue were identified – at least one characteristic particle was identified and confirmed with the presence of other particles consistent with a gunshot residue type environment (i.e. SbBa, BaPb, PbSb, and/or other elements or element composites routinely found in GSR particle populations).
- Particles indicative of gunshot residue were identified – two or more indicative particles that cumulatively contain all three elements (Pb, Sb, and Ba) were identified and confirmed.
- Particles consistent with the cartridge case found in the case were detected.
- Insufficient gunshot residue particles were identified – No highly specific or indicative particles were identified, or indicative and/or highly specific particles were deemed questionable with justification.

Acceptable reasons for justification include, but are not limited to, low peak response or analytical difficulties not due to user error. These reasons will be documented and included in the analyst's notes.

6.2.8.3 Reporting Suggestions

6.2.8.3.1 *Suspect Clothing*

- Particles characteristic of gunshot residue were identified: “The clothing (or item) was examined for the presence of particles that would indicate involvement with a firearm discharge. Particles characteristic of gunshot residue were found on the (area of item/s). The presence of these particles may be the result of discharging a firearm, being in close proximity to a firearm at the time of discharge, or contacting a surface bearing gunshot residue.”
- Insufficient gunshot residue particles were identified: “The clothing (or item) was examined for the presence of particles that would indicate involvement with a firearm discharge. Insufficient gunshot residue particles were identified. The results may be considered negative. A negative gunshot residue result cannot support the conclusion that a person did not discharge a firearm.”

6.2.8.3.2 *Gunshot Residue Kits*

- Particles characteristic of gunshot residue were identified: “The gunshot residue kit sampled from (name of person sampled) was examined for the presence of particles that would indicate involvement with a firearm discharge. Particles characteristic of gunshot residue were found on the (right and/or left hands). The presence of these particles may be the result of discharging a firearm, being in close proximity to a firearm at the time of discharge, or contacting a surface bearing gunshot residue.”

- Insufficient gunshot residue particles were identified: “The gunshot residue kit sampled from (name of person sampled) was examined for the presence of particles that would indicate involvement with a firearm discharge. Insufficient gunshot residue particles were identified. The results may be considered negative. A negative gunshot residue result cannot support the conclusion that a person did not discharge a firearm.”
- Particles indicative of gunshot residue were identified: “The gunshot residue kit sampled from (name of person sampled) was examined for the presence of particles that would indicate involvement with a firearm discharge. Particles indicative of gunshot residue were found on the (right and/or left hands). The presence of these particles may be the result of discharging a firearm, being in close proximity to a firearm at the time of discharge, or contacting a surface bearing gunshot residue. Occupational and/or environmental sources cannot be excluded.”

6.2.3.2 Bibliography

- Andrasko, J. and A.C. Muehly, (1977). “Detection of gunshot residues on hands by scanning electron microscopy”, *J. Forensic. Science*. 22:279-287.
- Basu, S. (1982). “Formation of gunshot residues”, *J. Foren. Sci.* 27:72-91.
- White, R.S. and Owens, A.D. (1987). “Automation of gunshot residue detection and analysis by scanning electron microscopy/energy dispersive x-ray analysis (SEM/EDX)”. *J. Forensic Science*. 32:321-330.
- Smith, M.A. (1991). “Particle Analysis by the Scanning Electron Microscope”. *Proceedings of the International Symposium on the Forensic Aspects of Trace Evidence*, FBI Academy June 1991, p31-39.
- Wright, D. M., and Trimpe, M. A., “Summary of the FBI Laboratory’s Gunshot Residue Symposium, May 31 – June 3, 2005”, *Forensic Science Communications*, Volume 8, Number 3, pp. 1 – 19.
- Torre, C., Mattutino, G., Vasino, V., and Robino, C., “Brake Linings: A Source of Non-GSR Containing Lead, Barium, and Antimony”, *Journal of Forensic Sciences*, (2002), Vol. 47, pp. 494-504.

6.3 Identification of Ignitable Liquids

The detection of ignitable fluids can be divided into training, assessment of evidence, extraction techniques, chromatographic analysis, interpretation of results, and reporting.

6.3.1 Training

An analyst must satisfactorily complete a regimen of training as outlined in the training manual before performing independent casework. Necessary training includes:

- Completion of the required reading relating to production and analysis of ignitable liquids.
- Learning to use the equipment involved with the analysis of ignitable liquids
- Working with a qualified examiner on arson cases
- Passing a written exam and proficiency test(s)
- Moot court if necessary.

6.3.2 Evidence Assessment

Several criteria must be met for a satisfactory analysis of evidence to be performed:

- The evidence must be in a well-sealed airtight container to protect the integrity of the evidence and the validity of the result.
- The evidence items should be individually marked with identifiers that allow differentiation of each item, such as a case number and an evidence number (E number). If the items of evidence are not individually labeled, then they must be labeled by the analyst.
- The outermost layer of the packaging must be sealed.
- There must be no evidence of cross-contamination.

If any of these criteria are not met then the evidence may be returned untested.

6.3.3 Preparation and Sampling Technique

Once evidence is determined to be acceptable for analysis, a method of extraction must be chosen. This is dependant upon the nature of the evidence and of the packaging. The method of choice is heated passive adsorption. If the sample should not be heated, as is the case with evidence that is assigned to another section such as forensic biology or latent prints but has not been tested, then an ambient passive adsorption is acceptable. Direct analysis of flammable liquids is usually preferable, although ambient or heated passive adsorption may be performed in lieu of or in conjunction with direct sampling. If none of these techniques are practical, headspace or a solvent wash may be used.

The method of analysis is gas chromatography-mass spectrometry (GC-MS). In certain cases where this method fails to detect an ignitable liquid because of the constraints of the instrumental parameters, other methods such as vapor-phase infrared spectroscopy may be used.

6.3.4 Testing Techniques

- All reagents used will be at least Reagent Grade, unless specified otherwise.

6.3.4.1 Passive Adsorption

Procedure:

- The container is briefly opened noting the presence of any characteristic odors.
- A charcoal strip attached to a bent paper clip is placed in the container by a string.
- For heated passive adsorption, the container is resealed and placed into an oven with temperature between 60° C and 70° C for a minimum of four hours. The container may be left overnight.
- For ambient passive adsorption, the container is resealed and left at room temperature for a minimum of sixteen hours.
- If heated, the container is removed from the oven and allowed to cool.
- The adsorbent material is removed and placed in an injection vial.
- The adsorbent material is eluted with a small amount of carbon disulfide.
- The eluent is analyzed by gas chromatography-mass spectrometry (GC-MS).

6.3.4.2 Solvent wash or solvent extraction

This is a very sensitive technique which can be very useful for the extraction of nonporous surfaces and very small samples.

Procedure:

- Place as much of the sample as is practical into a clean beaker.
 - If possible select a representative portion of the sample.
 - If only a representative portion is extracted, include which portion in notes.
- Pour a small amount of pentane or carbon disulfide over the sample.
- Decant the solvent into a separate clean beaker.
- Evaporate the solvent to a small volume to concentrate any ignitable liquid residues that may be present.
- The solvent blank shall be treated in the same manner as the sample.
- Analyze by gas chromatography-mass spectrometry.

6.3.4.3 Headspace

The procedure is useful when volatile oxygenated products are suspected. It is the least sensitive technique but the sample remains in approximately the same condition in which it was submitted therefore repeat analyses are possible.

Procedure:

- Punch a hole in the top of the lid and cover hole with tape or place a rubber sleeve stopped in the hole.
- The container is placed in an oven with temperature between 60° C and 70° C until equilibrium is reached.
- Upon removal a gas-tight syringe is inserted through the tape or stopper into the hole. The syringe is pumped three times and then removed from the lid. The hole is resealed.
- The optimum sample size will vary with chromatograph column and conditions but should be 0.5 to 2.0 ml.

6.3.4.4 Direct Analysis

Procedure:

- Neat liquid samples are diluted with carbon disulfide and analyzed via gas chromatography-mass spectrometry.

6.3.5 Validation

- ASTM E 1618-06e1: Standard Test Method for Ignitable Liquid Residues in Extracts from Fire Debris Samples by Gas Chromatography-Mass Spectrometry
- ASTM E 1386-05: Standard Practice for Separation and Concentration of Ignitable Liquid Residues from Fire Debris Samples by Solvent Extraction
- ASTM E 1387-01: Standard Test Method for Ignitable Liquid Residues in Extracts from Fire Debris Samples by Gas Chromatography
- ASTM E 1388-05: Standard Practice for Sampling of Headspace Vapors from Fire Debris Samples
- ASTM E 1412-07: Standard Practice for Separation of Ignitable Liquid Residues from Fire Debris Samples by Passive Headspace Concentration with Activated Charcoal.

6.3.6 QA/QC

- A sample of alcohols, gasoline, and diesel fuel will be run at the beginning and end of each sequence to ensure the reproducibility of chromatographic patterns.
- A sensitivity standard (ASTM E 1387) will be run with each sequence to ensure minimum detection limits and reproducibility of retention times.
- The resulting chromatograms of these samples will be filed in a location near the chromatograph.
- Logbooks will be kept containing the use and maintenance of the GC-MS, the results of each GC-MS autotune, and the printouts of the standards for each GC-MS sequence.

- For quality assurance, each arson case must include (where appropriate):
 - A solvent blank to ensure the solvent used for elution or extraction was free of contamination. There must be a solvent blank for each solvent used.
 - A solvent elution of a sample of the charcoal adsorbent used for the ignitable liquid residue extraction to ensure the charcoal adsorbent was free of contamination. (n.b.: These first two steps can be combined into one chromatographic analysis.)
 - A blank for any case where evidence is repackaged in another container for analysis. An identical, but empty, container from the same batch must be analyzed in the same manner as the evidence to ensure that the containers are free of contamination.
 - Blanks for solvent extraction samples will consist of a volume of extraction solvent evaporated to the same volume as the analyte.
 - Blanks must be run between all samples when running in the auto sampler mode.

6.3.7 Notes / Documentation

Refer to section 4.3 of this manual for general guidelines for package description.

Notes must include:

- The case number assigned by the evidence receiving section.
- The name of the analyst performing the accelerant analysis.
- A description of the contents of each container, noting any strong odors.
- A notation of the recovery technique, with preparation and extraction details, used in the analysis.
- The results of the analysis.
- A notation showing whether the quality control samples were acceptable.
- Any comments by the analyst concerning the packaging or condition of the evidence, or of any variation from routine procedure.
- Gas Chromatograph/Mass Spectrometer (GC-MS) spectra
 - A full-scale total ion chromatogram (TIC) of the unknown sample showing the entire chromatogram.
 - An extracted ion chromatogram (EIC) of the unknown sample, using ions illustrative of the classification of the unknown sample (see table below) for all positives.
 - An EIC of a primary standard, using ions illustrative of the classification of the primary standard (see table below) for comparison with the unknown sample.
 - A blank chromatogram of the solvent used in the extraction, run immediately before the analysis of the unknown sample.

6.3.8 Assessment of Results

6.3.8.1 Review of Data

All peaks used to determine the presence or absence of an ignitable liquid must be identified by their mass spectrum. This may be done by pattern-matching the extracted ion chromatograph for selected ions with that of a known primary standard of an ignitable liquid or by identifying specific compounds by their mass spectrum and comparing these to that of a known primary standard.

Characterization of ignitable liquids by class should be done in accordance with the ASTM Ignitable Liquid Classification Scheme. (Section 10.2 of ASTM E1618-06e1).

Compound Class	Ions of Interest for Petroleum Distillates
Alkane	43, 57, 85, 99
Aromatic	91, 105, 119
Cycloparaffin	55, 69, 83
Naphthalene	128, 142, 156

Compound Class		Ions of Interest for Gasoline
Alkane		43, 57, 71, 85
Aromatic	Alkylbenzene	91
	C ₂ Benzenes	106
	C ₃ Benzenes	120
	C ₄ Benzenes	134
Naphthalene	Naphthalene	128
	Methylnaphthalene	142

chromatogram with no significant peaks may be reported as negative given that all QA/QC checks were acceptable.

- A chromatogram with significant peaks which may be attributed to the sample matrix but that do not match that of an ignitable liquid may be reported as negative given that all QA/QC checks were acceptable.
- A chromatogram with significant peaks not attributed to the sample matrix that do not match that of an ignitable liquid may be reported as inconclusive given that all QA/QC checks were acceptable.
- A chromatogram with significant peaks that match that of an ignitable liquid that are not attributed to the sample matrix may be reported as positive for that class of ignitable liquid given that all QA/QC checks were acceptable.

6.3.8.2 Report Wording Suggestions

6.3.8.2.1 Negative

- No ignitable liquid residues were detected in item ().
- Ignitable liquids may evaporate or can be totally consumed during a fire. A negative result does not preclude the presence of an ignitable liquid during a fire.

6.3.8.2.2 Light Petroleum Distillate

- Item () contained residues consistent with the light petroleum distillate class of ignitable liquid.
- A residue of a light petroleum distillate was detected in item ().
- Examples of a light petroleum distillate include some camp fuels, cigarette lighter fuels, petroleum ethers, VM&P naphthas, rubber cement solvents, stove fuels, and lantern fuels.

6.3.8.2.3 Gasoline

- Item () contained residues consistent with gasoline.
- A residue of gasoline was detected in item ().

6.3.8.2.4 Medium Petroleum Distillate

- Item () contained residues consistent with the medium petroleum distillate class of ignitable liquid.
- A residue of a medium petroleum distillate was detected in item ().
- Examples of a medium petroleum distillate include some charcoal starters, paint thinners, dry-cleaning solvents, torch fuels, lamp oils, camp fuels, insecticides, polishes, and mineral spirits.

6.3.8.2.5 Heavy Petroleum Distillate

- Item () contained residues consistent with the heavy petroleum distillate class of ignitable liquids.
- A residue of a heavy petroleum distillate was detected in item ().
- Examples of a heavy petroleum distillate include kerosene, some lamp oils, furniture treatments, some fuel oils, and Diesel fuel.

6.3.8.2.6 Isoparaffinic Products

- A residue of an isoparaffinic product was detected in item ().
- Note: may be designated as light, medium, or heavy range.
- Examples of isoparaffinic products include aviation gasoline, some charcoal starters, some paint thinners, some copier toners, and some specialty solvents.

6.3.8.2.7 Aromatic Products

- A residue of an aromatic product was detected in item ().
- Note: may be designated as light, medium, or heavy range.
- Examples of aromatic products include some paint and varnish removers, some automotive parts cleaners, xylene and toluene-based products, some specialty cleaning solvents, some insecticide vehicles, and fuel additives.

6.3.8.2.8 Naphthenic-Paraffinic Products

- A residue of a naphthenic-paraffinic product was detected in item ().
- Note: may be designated as light, medium, or heavy range.

- Examples of naphthenic-paraffinic products include cyclohexane based solvents, some charcoal starters, some insecticide vehicles, some lamp oils, and some industrial solvents.

6.3.8.2.9 Normal Alkane Products

- A residue of a normal alkane product was detected in item ().
- Note: may be designated as light, medium, or heavy range.
- Examples of normal alkane products include solvents containing pentane, hexane, or heptane, some candle oils, some copier toners, and some carbonless forms.

6.3.8.2.10 Oxygenated Solvents

- A residue of an oxygenated solvent was detected in item ().
- Note: may be designated as light, medium, or heavy range.
- Examples of oxygenated solvents include alcohols, ketones, some lacquer thinners, some fuel additives, surface preparations solvents, some industrial solvents, metal cleaners, and gloss removers.

6.3.8.2.11 Miscellaneous

- Item () contained residues consistent with a miscellaneous class of ignitable liquids.
- Item () contained a miscellaneous class of ignitable liquids.
- Note: may be designated as light, medium, or heavy range.
- Examples of a miscellaneous class of ignitable liquids include single component products, some blended products, some enamel reducers, turpentine products, and some specialty products.

6.3.8.2.12 Inconclusive

Analysis of item () did not establish or exclude the presence of liquid accelerant residues.

6.3.8.2.13 Turpenes

Turpenes were identified in item (). Turpenes consistent with those detected are essential components of turpentine and are naturally occurring in some types of wood.

6.3.8 Bibliography

- FBI, Laboratory Analysis of Arson Evidence - Course Manual
- Forensic Science Handbook, Chapter 6 – Arson and Explosive Investigation, Richard Saferstein

6.4 Lamp Filament Examination

In many motor vehicle accidents, the question of “Were the lights on?” is among the questions asked of the laboratory. Many times the bulbs (or remains of bulbs) will be submitted to the lab having already been removed from the vehicle. It is the job of the trace evidence unit to examine these items and make a determination to best answer that question.

6.4.1 Training

In addition to the general guidelines found in section 2.3.1 of this manual, the analyst training in the examination of lamp filaments must:

- Complete the required reading relating to lamp filament examination.
- Have an understanding of different automotive lamp application and wiring schemes.

6.4.2 Evidence Assessment by Analyst

- The evidence should be in the same condition as the time it was collected
- The evidence should be properly labeled with the correct location of collection (i.e. front left bulb)
- The evidence should be packaged in a container to prohibit damage

6.4.3 Preparation and Sampling Techniques

- The bulb should be carefully removed from the packaging
- Note sampling information

6.4.3.1 Visual examination

Examine and record the following:

- The condition of the outer glass envelope (intact and sealed)
- The degree of darkening of the inside of the glass envelope and its location in relation to the filament(s)
- The condition of the terminal posts (distortion, fractures, and the presence or absence of deposits or debris)
- The condition of the filament(s) (distortion, fractures, degree of pitting on the surface, the presence or absence of interference colors and/or dulling, and deposits or debris present on the surface).

6.4.3.2 *Glass Envelope Removal*

- Intact sealed-beam headlamps usually necessitate the breakage of the outer glass envelope in order to make a more thorough examination of the filament(s) and terminal posts. The lamp is placed on a table, lens side down, and a circle is drawn with a suitable marker around the lamp surface approximately equidistant from the top and bottom edge of the lamp.

A diamond-tipped marker is used to scribe over the circle made by the ink marker. The vacuum inside the lamp should then be broken by crushing the glass tip located on the back of the lamp inside the triangle formed by the terminal lugs with a pair of pliers. A portable propane burner or charcoal igniter is used to heat the area outlined by the ink marker until all the color from the marker has disappeared. The lamp is quickly immersed in a pan of water, lens side first, utilizing a pair of pliers to hold one of the terminal lugs or a cold wet towel is thrown over the lamp. The lamp should fracture along the scribe marks. The portion of the lamp containing the terminal posts and filament(s) should be set on a table and allowed to cool. The other section after cooling should be checked for any loose parts from the inside of the lamp and retained for inclusion upon completion of the analysis.

- Usually small lamps do not require breakage of the envelope in order to complete the examination. Occasionally, filament parts have broken away from the terminal posts and may be hard to examine thoroughly. Small bulbs can be broken by first carefully wrapping plastic food wrap around the glass portion to the copper base. The bulb then may safely be broken in a vice without losing valuable pieces of the bulb.

6.4.4 *Testing Techniques*

Multiple testing techniques are available to determine deformation, discoloring, deposition, and pitting. The analyst will determine which test(s) are appropriate for the particular case.

6.4.4.1 *Stereomicroscope*

A more detailed examination of small intact bulbs, broken small bulbs and sealed-beam headlamps, and miscellaneous lamp parts should be conducted utilizing a stereomicroscope at 10 to 40X magnification. The lamp should be examined for the same conditions as outlined in the previous section. In addition, the filaments should be checked for the presence of small glass chips and/or fused glass sticking to them. Particular attention should be paid to the kind of fracture(s) (jagged or bulbous) that may be present along the length of each filament.

6.4.4.2 Polarizing Microscope

The purpose of the polarizing microscope examination is to identify small particles that may be adhering to the filament but have not been fused. This test differentiates between particles of sand (quartz) and glass.

Any particle(s) in question should be carefully mounted on a microscope slide in a drop of Cargille refractive index liquid with a refractive index near 1.500. The slide is placed under a polarizing microscope and examined under crossed polars.

Glass particles will remain dark with the rotation of the circular stage while sand particles will exhibit birefringence.

6.4.4.3 Scanning Electron Microscope

The advantage of the scanning electron microscope in the examination of filaments from lamps is its great depth of focus over the range of magnifications utilized. In addition, the SEM is useful for examining filaments for signs of age and fatigue as well as a more careful study of its fractured ends.

The filament piece is carefully mounted on a carbon stub using double-sided sticky tape. The sample stub is placed in the microscope chamber and examined at low to medium magnifications. Aged filaments will show a terraced surface and lack the strongly delineation produced by the extrusion process. Cold fractures will show a rough break usually along the crystalline planes of the wire. Hot failures will appear bulbous and smooth.

6.4.4.4 Continuity Test

The purpose of the continuity test is to determine whether the lamp is still operational and may be conducted on lamps that still have the outer glass envelope, filament(s), and terminal posts intact.

An ohmmeter may be used to verify each filament circuit by testing for a low resistance through each circuit. In the case of small bulbs one connection should be made at one of the contact points on the bottom of the bulb and the other connection made with the copper shell at the base of the bulb.

In the case of a single beam headlamp the connections of the ohmmeter should be made at each of the two lugs on the back of the lamp. In the case of a dual beam headlamp there are three lugs in a triangular shape on the back of the lamp. The connection to the top lug and the left bottom lug complete the low beam circuit. The connection to the top and right bottom lugs completes the high beam circuit. An ohm reading near zero indicates an intact circuit (and thus filament) and a high reading (of many ohms) indicates a broken circuit and/or filament.

6.4.5 Validation

Examination will be conducted following documented techniques according to training and/or literature.

- Baker, J. Stennard “Lamp Examination for On and Off in Traffic Accidents.” Topic 823 of the Traffic Investigation Manual”, The Traffic Institute, Northwestern University Evanston Illinois 60204, 1986.

6.4.6 QA/QC

- Analyst will label each item.
- Examination area should be cleaned and paper changed between evidence items.
- Care should be taken not to further break or damage any item.
- Quality assurance guidelines for microscopes found in section 7.2 of this manual should be followed.

6.4.7 Notes/ Documentation

- Detailed notes should be taken of packaging including possible information as to sampling location.
- Refer to visual examination (6.4.3.1).
- Diagrams may be completed to indicate noticeable deformation and configuration of bulbs during examination.
- Photographs may be taken to further show deformation or other conditions of the bulb.

6.4.8 Assessment of Results

Reporting Suggestions

- Microscopic examination of the (single/dual) filament lamp (E#) revealed characteristics consistent with (the filament/both filaments) being incandescent at the time of an impact.
- Microscopic examination of the (single/dual) filament lamp (E#) revealed no characteristics consistent with (the filament/both filaments) being incandescent at the time of an impact.

6.4.9 Bibliography

- Baker, J. Stennard “Lamp Examination for On and Off in Traffic Accidents.” Topic 823 of the Traffic Investigation Manual”, The Traffic Institute, Northwestern University Evanston Illinois 60204, 1986.
- Fries, Thomas R. and Richard O. Lapp “Accident Reconstruction – Response of Halogen Light Filaments during Vehicle Collisions.” SAE Paper 890856.
- Greenlay, W.R.A., M. Juzkow, S.R. Mikkelsen and A.D. Beveridge “The Effect of Impact on the Filaments of Quartz Halogen Headlamps.” Canada Journal of Forensic Science May 1986.
- Kawakami, Akira and Hidenobu Sekimori “Accident Information for Traffic Accident Reconstruction – The Role of the Automobile Lamp Filament.” SAE Paper 930661.
- Keskin, A. Tanner, Walter S. Reed, and Richard L. Friedrich “Brake Light Filament Deformation Analysis for Vehicular Collisions.” SAE Paper 880233.
- Haas, M.A., M.J. Camp, and R. F. Dragen “A Comparative Study of the Applicability of the Scanning Electron Microscope and the Light Microscope in the Examination of Vehicle Light Filaments.” Journal of Forensic Science 15 April 1974.
- Severy, “Headlight-Taillight Analysis from Collision Research.” SAE Paper 660786, 1967.
- Tobin, William A., “Noninvasive Evaluation of Vehicular Lamp Bulbs.” Crime Laboratory Digest, Vol.21 No.1, January 1994.

6.5 Paint Analysis

6.5.1 Training

- Training will be conducted by a qualified paint analyst.
- Completion of proficiency and written test(s)
- Moot court, if necessary.

6.5.2 Evidence Assessment by Analyst

- Determine which items are known samples and which items are questioned samples. If a known sample was not submitted, contact the investigating officer to determine if the sample can be obtained.
- Review submission information to determine which other sections will be analyzing evidence. Caution should be used to preserve evidence to be sampled by other sections.
- Determine if sample amount is adequate for analysis.

6.5.3 Preparation and Sampling Techniques

6.5.3.1 Recovery of Paint from Clothing and Objects

- Visually examine the item for paint.
- Remove any visible paint fragments with forceps or probes. Cut out any paint smears present if large chips are not found.
- Hang clothing items to be examined on a rod over a clean white sheet of butcher paper. Small items may be held over the paper.
- Use a spatula to tap the item and then scrape it.
- Collect the debris in an appropriate container.
- Examine the debris under the stereomicroscope.
- Remove any paint fragments with forceps and place in folded paper or a suitable container.

6.5.3.2 Collection of Known Paint Samples

- Sample should include all layers of paint and substrate, if possible.
- Collect known sample from near area of damage.

6.5.4 Testing Techniques

6.5.4.1 Physical Examination

- Examine the samples for a potential fracture match. (See Section 6.9)
- Identify the color of paint and if any metallic flakes are present. The color may also be identified by referencing the Munsell color system.

- Document the layer structure for the known and questioned paint samples by examining under a stereomicroscope. An angled cut may help to show the layer structure.
- Thin cross-sections may be cut by using a Teflon coated razor blade along an edge of the paint sample. The thin sections may be mounted in a suitable medium for examination with a comparison microscope using transmitted and/or reflected light.
- If differences are observed between the questioned and known samples, the samples are dissimilar. No further testing is needed.

6.5.4.2 Instrumental Analysis

- Analyze organic components of individual layers of paint using the micro-FTIR.
- Inorganic components may be tested using MSP, SEM/EDS, and/or PLM.

6.5.5 Validation

- “Trace Evidence Recovery Guidelines,” Technical Working Group on Materials Analysis, Evidence Handling Committee, FBI, January 1998.
- “Forensic Paint Analysis and Comparison Guidelines,” SWGMAT, Federal Bureau of Investigation, Jan. 1999.
- ASTM E1610-95 (2001) Standard Guide for Forensic Paint Analysis and Comparison.

6.5.6 Quality Assurance/Quality Control

- Collect known paint samples using a new scalpel or razor blade.
- Examination area should be cleaned and paper changed between known and questioned items.
- Change gloves and clean tools between examining known and questioned items.
- Follow Quality Assurance/Quality Control guidelines established in each instrument section.

6.5.7 Notes/Documentation

- Evidence and packaging should be documented.
- Notes on layer structure and other physical characteristics should be taken.
- Paint Worksheet may be included.
- FTIR spectra
- MSP spectra (if taken)
- Photographs may be taken.

6.5.8 *Assessment of Results*

6.5.8.1 Review of Data

- If physical characteristics are dissimilar, no additional analysis needs to be performed. If only a small fragment is recovered, additional analysis may be necessary.
- Compare the data of the questioned sample versus the known sample.
- If no significant differences exist between a questioned and known sample, they may be reported as being similar.
- A PDQ search may be conducted on questioned layered automotive samples.

6.5.8.2 Reporting Suggestions

- Single-layer samples: The (color) paint in item () was microscopically and analytically similar to the known paint sample from item ().
- Multi-layer samples: The (color) paint in item () consisted of (number) layers of paint which were microscopically and analytically similar to the (number) layers of paint in the known paint sample from item ().
- Smears: (Color) smears were located on item (). These paint smears were similar in color to the paint from item (). However, due to the lack of sample, no further examinations were conducted.
- Disclaimer: It is noted that paint cannot be positively identified as coming from a particular vehicle (or source) to the exclusion of all other vehicles (or sources) with the same paint.
- Dissimilar: The (color) paint in item () was microscopically and/or analytically dissimilar to the (color) paint from item ().

6.5.9 *Bibliography*

6.5.9.1 References for Paint Analysis

- Ryland, S. G., "Infrared Microspectroscopy of Forensic Paint Evidence," Chapter 6, Humecki, H., Ed. Practical Guide to Infrared Microspectroscopy, Marcel Dekker, Inc., New York, NY, 1995, pp. 163-243.
- Thornton, J. I., "Forensic Paint Examination," Forensic Science Handbook, Vol. 1, Saferstein, R., Ed., Prentice-Hall, NJ, 1982, pp. 529-571.

6.5.9.2 Reference Collections

- "Paint Pigment Reference Set," McCrone Accessories & Components, Westmont, IL
- "Reference Collection of Automotive Paints," Collaborative Testing Services, Inc., Herndon, VA, 1974-1989.
- "Production Color Book," PPG Industries, Inc., 1982-2000.
- "Car Color List," PPG Industries, Inc., 1960-1998.
- "The Munsell Book of Color," Glossy and Matte Collections, Macbeth Division of Kollmorgen Instruments Corp., New Windsor, NY.
- Paint database collected by the Arkansas State Crime Laboratory.
- Paint Database Query samples; Database maintained by the RCMP.

6.6 Collection of Hairs and Fibers

6.6.1 Training

- Training in the collection of hairs and fibers by a qualified analyst.
- Completion of proficiency and written test(s)
- Moot court, if necessary.

6.6.2 Evidence Assessment by Analyst

- Hairs and fibers should not be collected on items where the victim and suspect are co-habiting. It may be necessary to examine some items (i.e. murder weapon) for a transfer of hairs and/or fibers.
- Determine which items are from the victim, suspect, scene, etc.

6.6.3 Preparation and Sampling Techniques

- Follow the procedures under “Testing Techniques”, Section 6.6.4.
- If collection has occurred previously, refer to the appropriate analysis section in this manual.

6.6.4 Testing Techniques

6.6.4.1 Collection from Sexual Assault Kits

- Examine the contents of the sexual assault kit to locate the “Pubic Hair Combing” envelope and “Underwear” bag. Also note any extra items that may have been included for hair and fiber examination.
- If samples were not collected according to the information supplied on the package, no further analysis is needed for that item. Record in notes.
- Open the “Pubic Hair Combing” envelope and remove all hairs from the comb, cotton, and/or napkin. Place the hairs in a folded piece of paper or tissue and package in a labeled coin envelope. Return the “Pubic Hair Combing” envelope to the kit.
- Examine the underwear according to the procedures listed in section 6.6.4.2 and return to the kit.
- Place envelopes and/or tape lift transparency sheets in a manila envelope.

6.6.4.2 Collection from Clothing or Other Items

- Visually examine item and note description of item and fabric content, if listed.
- Take care to preserve evidence that other sections may need to examine (i.e. blood stains, latent prints, etc.). It may be necessary to collect fibers and/or hairs with forceps and place in an envelope or on tape rather than taping the item directly.

- A section of clear adhesive tape is pressed on the item and pulled away. Fibers and/or hairs adhere to the tape which is then placed on a clear transparency sheet. Continue collecting with sections of tape until the entire item has been covered.
- Label the tape lifts on the transparency sheet.
- Known samples of all the fiber types and colors are cut from the item and placed on the transparency sheet with clear tape or in an envelope. White cotton, denim, light-colored fabrics and smooth fabrics (such as nylon windbreakers) are not suitable target fibers.
- Place transparency sheets and/or envelopes in a manila envelope.

6.6.5 Validation

- ASTM E1492-05 Standard Practice for Receiving, Documenting, Storing, and Retrieving Evidence in a Forensic Science Laboratory.
- “Trace Evidence Recovery Guidelines”, Technical Working Group on Materials Analysis, Evidence Handling Committee, FBI, January, 1998.

6.6.6 Quality Assurance/Quality Control

- Examine items over clean white paper.
- Victim and suspect items should be collected in different rooms.
- Change lab coats, gloves, and other supplies between examination of items from victim and suspect.
- Maintain adhesive tape in a manner to avoid contamination.
- Review list of other sections to examine each item.
- Examine only one kit at a time.
- Do not cut known samples from areas which may contain biological stains.
- Follow biohazard procedures and practice universal safety precautions when examining evidence.

6.6.7 Notes/Documentation

- Evidence and packaging should be noted.
- Photographs or photocopies of the items and/or packaging may be taken
- Describe items and include fabric content, if labeled.

6.6.8 Assessment of Results

6.6.8.1 Review of Evidence Collected

- Review evidence which was collected.
- If known samples are present and/or additional work needs to be completed, continue to the appropriate analysis section or turn the case over to the section supervisor for reassignment.
- If known samples were not submitted, write report requesting known samples (if needed).

6.6.8.2 Report Writing Suggestions

- Tape lifts were collected from the items listed. They are being retained.
- Hairs and/or fibers were collected from the items listed. They are being retained.
- If further analysis is desired, the following items are needed: (may request one or more of the following)
 - Head hair sample (40 – 60 pulled hairs) from the victim and any suspects.
 - Pubic hair sample (30 – 40 pulled hairs) from the victim and any suspects.
 - Fiber samples (clothing, carpet, etc.) from any suspects.

6.6.9 Bibliography

6.6.9.1 References For Collection From Clothing Or Other Items

- “Fiber Guidelines”, Technical Working Group for Materials Analysis, January 1998.

6.7 Macro/Microscopic Hair Examination

6.7.1 Training

In addition the general guidelines outlined in section 2.3 of this manual, the hair analyst must:

- complete training in Collection of Hairs and Fibers in this manual (section 6.6.1).
- be trained by a qualified analyst in microscopic hair analysis
- be able to collect and mount hairs on microscope slides
- use the microscopes in the section.
- have a general knowledge about hair growth and the microscopic characteristics of hair.

This is one of the more difficult examinations in Trace Evidence and usually requires a year or more before an examiner can perform independent casework.

6.7.2 Evidence assessment

Several criteria must be met for a satisfactory analysis to be performed; refer to the Collection of Hairs and Fibers Section of this manual (section 6.6.2):

- the evidence must be in a sealed container
- items of clothing must be dry
- suspect items must be packaged separately from victim items

If any of these criteria are not met, the evidence may be returned untested.

6.7.3 Preparation and Sampling Techniques

Each case may present new challenges concerning sampling techniques due to condition of evidence when officers obtain it or due to handling of the evidence. Each analyst will have to determine the proper sample preparation methods to utilize for each item. When deviation from the normal procedure is required, the proper documentation should be included in the file.

6.7.3.1 Collection

Refer to the Collection of Hairs and Fibers Section of this manual (section 6.6).

Items to be examined for hairs should be placed on a white sheet of paper in a brightly lit examination room. The item and packaging should be labeled with the case number, item number and initials of the analyst.

Hairs may be collected with forceps or clear packing tape. Loose hairs should be placed in coin envelopes. Tape lifts should be attached to glass slides or acetate sheets and placed in envelopes. It should be determined whether items originating from a crime scene belong to the suspect or the victim. Items from the suspect should be examined in a different room than the items from the victim.

Lab coats, gloves, tape dispensers and other supplies should be changed between examinations of victim and suspect items. No examination should be performed on items where the victim and suspect are co-habiting.

6.7.3.2 Preparation and Mounting of Hairs

The analyst should first determine which hairs are suitable for examination. Very small fragments or debris hairs may not need to be mounted for examination. Suitable standards are needed before any comparisons may be performed.

A head hair standard should consist of fifty to sixty hairs pulled from different areas of the head. These areas include the front, back, top, left side and right side. All hairs from the head of an individual may be placed in one envelope. This standard should represent all types of hair on the head.

A pubic hair standard should consist of thirty to forty pulled hairs from different areas of the pubic region.

A sample of the standard representing different colors and lengths of hair should be mounted. Permunt should be used as a mounting medium. Three-by-two inch glass slides should be used along with 45x50 mm coverslips.

Small hairs may be mounted on smaller slides. Hairs should be mounted so that they do not have frequent crossovers. Bubbles in the mounting medium are to be avoided. The ends of the hairs should not stick out from under the coverslip.

Slides should be clearly labeled with case number, item number, analyst's initials and date mounted. Questioned hairs should be mounted in a similar manner.

Questioned hairs may be screened with a stereomicroscope before determining which hairs to mount.

When slides are dry, a photocopy of the slide should be made for documentation of the slide and for note taking of the comparison.

6.7.4 Testing techniques

- Animal hairs may be identified by stereomicroscopy or by mounting and examining by light microscopy.
- A comparison microscope is used for hair comparisons. The analyst should look for similarities and differences in color, length, diameter, condition, medulla, cuticle, cortex, presence or absence of ovoid bodies, cortical fusi, damage, chemical treatment, shape of root, shape of distal end, body area of origin, possible racial origin, etc.
- If there is tissue present on the root or shaft of the hair, the hair may be sent to the DNA section for analysis. If samples from a case have already been examined by DNA, the hair may not be needed.

6.7.5 *Validation*

Microscopy of Hair, A Practical Guide and Manual, John W. Hicks, Federal Bureau of Investigation, Issue 2, January 1977.

Forensic Science Handbook, Richard Saferstein, Editor, Volume 1 Second Edition, Prentice Hall, 1998, pp. 389-428.

6.7.6 *Quality Assurance of Hair Cases*

6.7.6.1 Physical Evidence

Items will be opened one at a time in a clean room over clean white paper. Hairs will be collected and items will be labeled with case number, item number and analyst's initials.

Items from the victim and suspect will be analyzed in separate rooms. It is preferable to wait several days between examination of victim's items and suspect's items. Lab coats, gloves, and supplies should be changed between victim and suspect items.

6.7.6.2 Analysis

Photocopies are made of each slide after mounting and drying. A second examiner will examine each hair determined by the original examiner to be important to the case unless there are a large number of similar hairs and then a representative sample will be examined by the second analyst. The second opinion will be documented on the photocopy of the slide.

6.7.7 *Notes*

Notes must include the general guidelines covered in section 4.3 of this manual.

Notes covering the examination should be made at the time of examination. Notes should include but not be limited to possible racial origin, probable body area, type of root present, and whether the hair is consistent with the standard.

Unusual characteristics that helped the examiner to come to a decision should also be noted. Points of interest on the hair may be marked on the slide or the notes. Any comparison that is deemed important by the examiner (i.e. hair found on the victim which is consistent with the suspect) should have a second examination by another hair analyst. This examination should also be documented in the notes.

6.7.8 *Assessment of Results*

6.7.8.1 Review Data

- Determine if a questioned hair and any known hair samples are microscopically similar or microscopically dissimilar or inconclusive.

- Determine if the hair is suitable for nuclear DNA testing. If so, inform the DNA section to see if the hair is needed.
- Occasionally, it may be requested that hairs be sent to the FBI or a private laboratory for mitochondrial DNA analysis. Hairs need to be a minimum of 2 cm for mtDNA testing.

6.7.8.2 Reporting Suggestions

Positive association: (Number) (body area) hairs indicative of (racial origin) were microscopically similar to the known hairs from (individual).

Negative Association: (Number) (body area) hairs indicative of (racial origin) were microscopically dissimilar to the known hairs from (individual).

Disclaimer: It is pointed out that microscopic hair analysis is not a basis for personal identification.

6.7.9 Bibliography

Microscopy of Hair, A Practical Guide and Manual, John W. Hicks, Federal Bureau of Investigation, Issue 2, January 1977.

Forensic Science Handbook, Richard Saferstein, Editor, Volume 1 Second Edition, Prentice Hall, 1998, pp. 389-428.

Chemical and Physical Behavior of Human Hair, Second Edition, Clarence R. Robbins, Springer-Verlag, 1988.

6.8 Fiber Analysis

6.8.1 Training

- Completion of training in “Collection of Hairs and Fibers”, Section 6.6.1.
- Training by a qualified analyst in fiber analysis.
- Completion of proficiency and written test(s).
- Moot court, if necessary.
- “Applied Polarized Light Microscopy” at McCrone Research Institute, Chicago, IL is recommended.

6.8.2 Evidence Assessment by Analyst

- Refer to “Collection of Hairs and Fibers”, Section 6.6.2.
- Review known samples to determine if suitable target fibers exist.

6.8.3 Preparation and Sampling Techniques

6.8.3.1 Collection of Fibers

Refer to “Collection of Hairs and Fibers”, Section 6.6.

6.8.3.2 Mounting Fibers

- Known fiber standards are examined using a stereomicroscope. Tape lift sheets from questioned items are examined for any fibers similar in macroscopic appearance to the known fibers.
- Questioned fibers may be circled on the transparent sheet or immediately removed.
- Mount the fibers in a suitable temporary mounting medium. Mount a representative sample of the known fibers using the same mounting medium.
- After analysis is completed, fibers should be mounted for permanent storage in Permout or Meltmount.

6.8.4 Testing Techniques

6.8.4.1 Polarizing Light Microscopy

- Place slide on the stage of the polarizing light microscope.
- Determine if the fiber is animal (i.e. wool), natural (i.e. cotton), or synthetic (i.e. polyester).
- Identify microscopic color and determine if pleochroism exists.
- Measure the diameter of the fibers in μm . A diameter range should be determined for known fiber samples.
- Determine the cross-section. If necessary, a cross-section may be cut with a scalpel or by placing the fiber between two sheets of a polyolefin material. The polyolefin is placed between two glass slides and heated on a hot plate. Pressure is applied with the eraser of

a pencil until the polyolefin melts together to take on a translucent appearance. Cool the slides and then slice thin cross-sections of the embedded fiber. Mount the cross-sections in a suitable mounting medium for microscopic examination. A sketch of the cross-section may be helpful.

- If the fiber is animal or natural, proceed to the next section. For synthetic fibers, additional microscopic data should be collected.
- Make note of any delusterants present.
- Determine the birefringence and sign of elongation by inserting the analyzer and compensator. Refer to the Michel-Lévy chart.
- Observe the relative refractive index in both the parallel and perpendicular directions.
- If possible, identify the fiber based on microscopic characteristics.
- Compare the questioned and known samples.

6.8.4.2 Microspectrophotometry

- The dye in colored fibers may be tested. Not all fibers are suitable for testing of the dye.
- Absorbance or transmission spectra of the dye from the questioned and known samples are obtained.

6.8.4.3 Fourier-Transform Infrared Spectrometry

- The fiber is removed from the slide and a small piece is cut from the end.
- The fiber may be flattened and placed on a KBr disc or other platform suitable for microscopic FTIR analysis.
- Obtain a spectrum.
- Determine the fiber type. Known library standards may be used for reference.

6.8.5 Validation

- “Forensic Fiber Examination Guidelines”, Technical Working Group for Materials Analysis, January 1998.
- ASTM E2228-02 Standard Guide for the Microscopic Examination of Textile Fibers.
- ASTM E2224-04 Standard Guide for Forensic Analysis of Fibers by Infrared Spectroscopy.
- ASTM E2225-02 Standard Guide for Forensic Examination of Fabrics and Cordage

6.8.6 Quality Assurance/Quality Control

- Keep known and questioned fiber tape lifts separated.
- Clean instruments between use on known and questioned samples.
- Mark all slides with case and item numbers.
- Refer to Calibration and Maintenance Sections 7.3.1 and 7.5.1.

6.8.7 Notes/Documentation

- Refer to “Collection of Hairs and Fibers”, Section 6.6.7.
- Fiber Worksheet
- MSP and FTIR spectra (if taken)

6.8.8 *Assessment of Results*

6.8.8.1 Review Data

- Determine if known and questioned samples are the same fiber type.
- Determine if the dye is similar between the questioned and known samples.

6.8.8.2 Reporting Suggestions

- Positive association: (Number) (color) (fiber type) fibers recovered from (questioned item) were microscopically and analytically similar to the (color) (fiber type) fibers used in the construction of (known item).
- Negative association: No similar fibers were found.
- Disclaimer: Fibers cannot be positively identified as having originated from a particular item to the exclusion of all similar items.

6.8.9 *Bibliography*

6.8.9.1 References for Mounting Fibers

- “Forensic Fiber Examination Guidelines”, Technical Working Group for Materials Analysis, January 1998.
- “An Improved Method for Rapid and Accurate Scanning of Fibers on Tape”, Journal of Forensic Science, Vol. 26, No. 3, July 1981, pp. 560-563.

6.8.9.2 References For Polarizing Light Microscopy

- McCrone, W. C., L. B. McCrone, and J. G. Delly, Polarized Light Microscopy, Ann Arbor Science Publishers, 1979.
- McCrone, W. C. and J. G. Delly, The Particle Atlas (electronic edition), MicroDataware, Inc., 1992.
- “A New Method for Cross-Sectioning Single Fibres”, Journal of Forensic Science, Vol. 32, No. 3, May 1987, pp. 761-767.

6.8.9.3 References for Microspectrophotometry

- “Dye Batch Variation in Textile Fibers”, Journal of Forensic Science, Vol. 33 No. 4, July 1988, pp. 998-1007
- “Assessment of the Value of Blue, Red, and Black Cotton Fibers as Target Fibers in Forensic Science Investigations”, Journal of Forensic Science, Vol. 33, No. 6, Nov. 1988, pp. 1332-1344.
- “The Definition of Colour for Single Textile Fibres by Microspectrophotometry”, Forensic Science International, 34 (1987) 107-129.

6.8.9.4 References for Fourier-Transform Infrared Spectrometry

- ASTM E2224-04 Standard Guide for Forensic Analysis of Fibers by Infrared Spectroscopy

6.8.9.5 References Collections

- “Reference Collection of Synthetic Fibers”, Collaborative Testing Services, Inc., McLean, VA, 1983 and 1986.
- “Fiber Reference Set”, McCrone Accessories & Components, Westmont, IL.
- “Particle Reference Set”, McCrone Accessories & Components, Westmont, IL.
- Fiber Database collected by Arkansas State Crime Laboratory.

6.9 Physical (Fracture) Matches

Physically matching the edge of a questioned item to the edge of a known item provides the only conclusive association between two samples. Fracture matches may be conducted on tape, glass, paint, plastic, or other items which have been broken, torn, or cut creating a unique edge.

6.9.1 Training

- Training conducted by a qualified expert.
- Pass proficiency and written test(s)
- Moot court, if necessary.

6.9.2 Evidence Assessment by Analyst

- The possibility of a fracture match should be the first consideration when examining evidence.

6.9.3 Preparation and Sampling Techniques

- Visually examine the evidence.

6.9.4 Testing Techniques

- The questioned and known samples should be placed in close proximity to insure that they have a unique edge in common.
- Photographs, photocopies, sketches, or other documentation should be taken.

6.9.5 Validation

- Accepted scientific practices should be used when examining physical matches.

6.9.6 Quality Assurance/Quality Control

- Review list of other sections to examine items. Ensure that the integrity of other evidence is not compromised in the analysis (i.e. fingerprints, blood, etc.).

6.9.7 Notes/Documentation

- Document the packaging and condition of the evidence.
- Photograph or sketch any fracture matches.

6.9.8 *Assessment of Results*

6.9.8.1 Review Data

- Examine fractures on other items if necessary.
- Determine if the fracture match is unique.

6.9.8.2 Reporting Suggestions

- The fractured (end, piece, cord, etc.) from the questioned item matched the fracture on the known item (i.e. roll of duct tape, broken vase, cord, etc.). These items were at one time joined.
- The fractured (end, piece, cord, etc.) from the questioned item did not match the fracture on the known item.

6.10 Indented Writing

6.10.1 *Training*

In addition to the general guidelines found in section 2.3.1 of this manual, the analyst training in the examination of indented writing must:

- Complete the required reading relating to ESDA examination.
- Be able to perform an ESDA examination.
- Complete of proficiency and written test(s)
- Moot court, if necessary

6.10.2 *Evidence Assessment by Analyst*

- The evidence should be in the same condition as the time it was collected
- The evidence should be properly labeled
- The evidence should be packaged in a container to prohibit damage

6.10.3 *Preparation and Sampling Techniques*

- The item should be carefully removed from the packaging
- Note sampling
- Gloves must be worn during examination.
- The outer packaging of the evidence will be marked while item is not inside it. Initials and dates on seals will be done in felt tipped permanent markers with very light pressure.
- Documents will not be folded or otherwise physically altered unless necessary to complete an examination. Permission must be obtained from the submitter prior to a necessary alteration, such as a page being removed from a notebook.

6.10.4 *Testing Techniques*

The analyst will determine which test(s) are appropriate for the particular case.

6.10.4.1 *Oblique Lighting*

Examine the paper from all angles using side lighting.

Use magnifiers or microscope if needed. If impressions are found, photograph using side lighting as required.

6.10.4.2 ESDA

Conduct ESDA (Electrostatic Deposition Apparatus) examination of documents that are suspected to have indented writing, even if nothing is noted with oblique lighting.

- Before examination with the ESDA the document will be put in the humidifier for 2 minutes. This assures that from day to day the papers tested are at the same humidity.
- The corona shall be passed over the document a minimum of 3 times.
- Create a permanent record by preserving the results with adhesive-backed clear acetate sheets. These results will be scanned into the case file. The ESDA lift will be considered evidence that will be itemized and retained or returned to the agency.

6.10.5 Validation

- ASTM E2291-03 Standard Guide for Indention Examinations

6.10.6 QA/QC

- Examination area should be cleaned and paper changed between evidence items.
- Care should be taken not to further break or damage any item.
- A small strip of paper will be folded lengthwise and ESDA Test, the date, and the analyst initials will be written on it using a ballpoint pen. This piece of paper will be unfolded and placed blank side up on the vacuum bed along with the first piece of evidence. This will ensure that the ESDA is functioning properly. The test strip will be documented by scanning in the case file.

6.10.7 Notes/ Documentation

- Detailed notes should be taken of packaging including possible information as to sampling location.
- The document should be photographed, photocopied, or scanned prior to examination to record its original appearance.
- Pictures of indentations viewed with oblique lighting will be scanned into the case file.
- ESDA lifts will be scanned into the case file.

6.10.8 Assessment of Results

Reporting Suggestions

- Deciphered text which is relevant to the investigation will be listed in the paragraph in its entirety.
 1. Example: Examination of exhibit Q1 (the letter) did not reveal any indented writing of evidentiary value.

2. Example: Examination of exhibit Q-1 revealed indented writing and was deciphered to read: “My name is John” and “555-0218”. Nothing more was decipherable.

6.10.9 Bibliography

- Nic Daéid, Niamh, “ESDA – The examination of indentations,” MSc in forensic science – Documents module. Forensic Science Unit, University of Strathclyde, 2004; 8-11.
- Foster, D.J. and Morantz, D.J., “An electrostatic imaging technique for the detection of indented impressions in documents,” *Forensic Sci. Int.* 1979; 13: 51-54.
- Baier, P.E., “Application of experimental variables to the use of the electrostatic detection apparatus,” *J. Forens. Sci.* 1983; 28(4): 901-910.
- Riebeling, I.J. and Kobus, H.J., “Some parameters affecting the quality of ESDA results,” *J. Forens. Sci.* 1994; 39(1): 15-20.
- Seward, G.H., “Practical implications of charge transport model for electrostatic detection apparatus (ESDA),” *J. Forens. Sci.* 1999; 44(4): 832-836.
- Moore, D.S., “The electrostatic detection apparatus (ESDA) and its effects on latent prints on paper,” *J. Forens. Sci.* 1988; 33(2): 357-377.
- Strach, S.J., McCormack, G.M., and Westwood, P.D., “Secondary indented writings – indented writing impressions caused by contact not by the act of writing,” *Advances in Forensic Sciences, Forensic Criminalistics 1*, 1995; 3: 295-296.
- Stach, S.J., “Statistical evaluation of a method for determining the sequence of writings on the front and back of one sheet of paper,” *Advances in Forensic Sciences, Forensic Criminalistics 1*, 1995; 3: 297-299.
- Strach, S.J., “ESDA detection of paper edges and folds,” *Advances in Forensic Sciences, Forensic Criminalistics 1*, 1995; 3: 300-301.
- Foster and Freeman LTD, “ESDA operating instructions,” Essex, England.

6.11 Miscellaneous Evidence Types

The Trace Evidence Unit will receive evidence that does not meet the description of other evidentiary categories.

These sample types may include, but are not limited to:

- Motor Oils
- Cosmetics
- Bank dyes
- Tapes and adhesives

6.11.1 *Training*

- Be proficient with general chemistry extraction methods
- Be proficient in the operation of different instruments including FTIR, SEM/EDS, GC/MS, TLC, and PLM
- Be familiar with the different literature, formulations, and manufacturing processes of motor oils, cosmetics, adhesive tapes, pesticides, and other matrices related to this type of analysis.

6.11.2 *Evidence Assessment*

Each type of sample requires special consideration. The examiner will determine the value of these samples and the method for analysis.

6.11.3 *Preparation and Sampling Techniques*

- Representative samples of the evidence should be obtained from relevant sample types.
- Controls should be obtained and analyzed where possible.

6.11.4 *Testing Techniques*

6.11.4.1 Determination of Testing Method

The examination of questioned samples may include:

- Macroscopic examination
- Stereomicroscopic examination
- Polarized light microscopy
- Comparison polarized light microscopy
- Microspectrophotometry
- Infrared microspectrophotometry

The analyst will determine a scheme for examination based on the type and amount of sample.

- A macroscopic examination will be performed.
- Evidence requiring a physical match will be compared to the known samples side by side both visually and stereomicroscopically.
- Evidence that appears to have color, such as cosmetics, will be examined with the microspectrophotometer and compared to a known sample.
- The resulting spectra will include operator, date, case, and item number.
- Particulate samples will be analyzed microscopically. If a known sample exists, the comparison microscope will be used to perform side by side microscopic comparisons. The comparison will be documented in the examiner's notes and/or with a color photograph.

6.11.4.2 Extraction Techniques

Evidence requiring chemical composition determination or comparison will be analyzed using accepted general scientific methods including, but not limited to:

- Spot tests
- GC/MS
- XRF
- EDS
- FTIR

6.11.5 Validation

- Analysis should follow generally accepted literature methods.
- Extraction and instrumental procedures should follow general chemistry methods.

6.11.6 QA/QC

- Work surfaces should be thoroughly cleaned prior to opening evidence.
- Evidence should be examined on clean white paper.
- Control samples and negative blanks will be included in analyses where possible.

6.11.7 Notes/ Documentation

- Notes sufficient to allow other qualified analysts to repeat and understand examination will be taken.
- Packaging information should be documented in the notes. Pictures may be taken as further documentation.

7.0 INSTRUMENT MAINTENANCE AND QUALITY CONTROL

7.1 Scanning Electron Microscope/Energy Dispersive Spectrometer

7.1.1 Performance Checks

- The detector's resolution should be measured and recorded in the log book each time the instrument is used. This is performed by measuring the fwhm (full width at half max) of the Cobalt peak collected on the calibration stub at 20 keV.
- The EDS calibration threshold levels should be set using the high Z/ low Z standard stub of cobalt and rhodium.
- To ensure proper EDS threshold setup for the EDS, a known sample of paint, glass, or gunshot residue particles should be analyzed before every sample run.
- The threshold and calibration checks are recorded as part of the INCA case file.
- The recipe and parameters should be verified monthly by analysis of a stub containing known gunshot residue particles of varying sizes (i.e. Plano stub). The INCA case file of this run is stored on the hard drive.

7.1.2 Maintenance

- Periodic maintenance (by a JEOL service technician) should include:
 1. Annual replacing of rough vacuum pump oil
 2. Annual calibration of SEM magnification
 3. Annual cleaning or replacing of final aperture
- Maintenance by laboratory personnel may include:
 - Replacing the filament and cleaning the wehnelt cap
 - Deicing the detector
 - Filling the dewar with liquid nitrogen

7.1.3 References

ASTM E 1588-07 Standard Guide for Gunshot Residue Analysis by Scanning Electron Microscopy – Energy Dispersive X-ray Spectrometry.

7.2 Microscopes (Stereo-, Comparison, Polarizing Light)

7.2.1 *Performance Checks*

- PLM eyepiece micrometers should be calibrated yearly for each objective using a stage micrometer. The conversion from units to micrometers should be documented in the logbook.
- Compound microscopes should be set with Köhler illumination. Each month that the microscope is used, document that Köhler illumination has been verified.

7.2.2 *Maintenance*

- Microscopes should be cleaned to remove dust.
- Light bulbs may need to be changed if a change in illumination is detected or if the bulb burns out.

7.2.3 *References*

- McCrone, Walter C., The Particle Atlas, 1967 (and other editions).

7.3 Fourier-Transform Infrared Spectrometer

7.3.1 Performance Checks

7.3.1.1 Bench

- Verification is performed by selecting (from the Spectrum pull-down menu) Instrument; Validate; Validate Instrument. This will test the abscissa, ordinate, and noise. A report is generated which will indicate a “PASS” or “FAIL” for each item. If any of the items is marked “FAIL”, the system should be examined for the problem and the verification rerun.
- The verification should be performed monthly before the instrument is used.

7.3.1.2 Microscope

7.3.1.2.1 Signal-to-Noise

- Signal-to-noise should be determined monthly before each use.
- Beam should be through the microscope with the path cleared for transmission, focused on the gold mirror for reflectance, or touching the gold mirror for ATR.
- Scan background using 100 x 100 μm aperture from 4000 to 500 cm^{-1} at a resolution of 1 cm^{-1} for 128 scans.
- Without a sample in place, scan ratio using the same parameters.
- Transfer the ratio spectrum to the Spectrum software. Save the file as S to N (date). View full scale from 2200 to 2100 cm^{-1} .
- Calculate the signal-to-noise ratio by dividing 141.4 (constant) by the difference of the y-axis. Signal-to-noise must be greater than 1000:1 to proceed with case work.

7.3.1.2.2 Polystyrene

- The polystyrene card (L120 2057) should be run monthly before using the micro-FTIR.
- Check peaks 3060, 1601, and 1028 cm^{-1} against reference. Peaks should fall within 1 cm^{-1} of these reference peaks.

7.3.2 Maintenance

7.3.2.1 Bench

- Desiccant should be changed as needed. A reminder will appear on screen.
- Refer to “Maintenance Guide” for advanced maintenance.

7.3.2.2 Microscope

- Clean cassegrain mirrors and other optics of the microscope with a stream of dry, clean, nitrogen gas (canned air) when needed.
- The detector may need periodic alignment. Refer to the “AutoImage Microscope Techniques and Maintenance Guide”, pp. 109 – 111.

7.3.2 References

- “Spectrum One Maintenance Guide”, PerkinElmer, Inc. 2000.
- “Spectrum One User’s Guide”, PerkinElmer, Inc. 2000.
- “Spectrum Software User’s Guide”, PerkinElmer, Inc. 2000.
- “AutoImage Microscope Techniques and Maintenance Guide”, PerkinElmer, Inc. 2000.

7.4 Glass Refractive Index Measurement System 2

7.4.1 Performance Checks

- Calibration of the instrument should be performed once a year. The standard curve for each oil and filter is recalibrated by running the series of known reference glasses in the corresponding silicone oil. The calibration curve is recorded in the GRIM2 software and documented in the logbook.
- Prior to each use, calibration of the instrument should be checked using one of the known reference glasses and the appropriate silicone oil.
- Once a month the calibration of the instrument should be checked using the SRM710 standard.
- The data for the SRM710 and the known reference glass is recorded in the logbook. The data for the known reference glass is printed with the case file.

7.4.2 Maintenance

- Dust the microscope, monitors, and computer as needed.
- Check the alignment of the microscope monthly when used. The microscope should be set for Köhler Illumination and phase contrast.
- Clean the hot stage sample holder as needed to remove excess silicone oil which may be deposited.

7.4.3 References

- “GRIM2 Installation & Instruction Manual”, Foster + Freeman, Version 4.0, November 1997.
- “GRIM2 Part Two: Application Notes”, Foster + Freeman, Version 1, March 2000.
- “Reference Glasses and Silicone Oils For Refractive Index Determination”, Locke Scientific.
- “Traceability of Locke Scientific Reference Glass Standards”, Locke Scientific.
- DAS Mikroskop Leica DML, Instructions, Leica Mikroskopie und Systeme GmbH, 2nd edition, 1997.
- “Operating Instructions Mettler Thermosystem FP800, FP800HT”, Mettler Instrumente AG, 1984.

7.5 Microspectrophotometer

7.5.1 Performance Checks

Performance checks are performed monthly when used with the NIST Traceable Filter Set Serial No. 128.

7.5.1.1 Wavelength Accuracy and Precision

- Holmium oxide has peaks in the UV and visible region and is used for calibration from 280 to 660 nm. Didymium has peaks in the visible and near IR region and is used for calibration from 440 to 880 nm.
- Place the clear quartz reference slide with the red dot on the stage and focus on the red ink.
- Set Köhler Illumination. Move the red ink out of the light path.
- Set “Parameters” to UV with a sampling frequency of 5.
- Block the light path and take a dark scan.
- Open the light path and take a reference scan.
- Place the holmium oxide filter over the field diaphragm and take a sample scan with %Transmission. The spectrum should be saved under c:\see\data\validation\holuv(date).
- Remove the filter and set the parameters to VIS/NIR. Use the “Autogain” to set the sampling frequency.
- Block the light path and take a dark scan.
- Open the light path and take a reference scan.
- Replace the holmium oxide filter over the field diaphragm and take a sample scan with %Transmission. The spectrum should be saved under c:\see\data\validation\hol(date).
- Place the didymium filter over the field diaphragm and take a sample scan with %Transmission. The spectrum should be saved under c:\see\data\validation\didy(date).
- Compare the wavelength values to the certified values. (May also be found and recorded in the Excel “Validation” spreadsheet.) Values should be within 3 nm.
- Record in QA/QC Logbook.

7.5.1.2 Photometric Accuracy and Precision

- Neutral density filters are characterized by a flat optical density in the 300 to 1000 nm region.
- Place the neutral density OD=0.1 filter on the field diaphragm and take a sample scan with Absorbance. The spectrum should be saved under c:\see\data\validation\nd01(date).
- Repeat using the OD=0.5 and OD=1.0 filters. Save these spectra using the notation nd05(date) and nd10(date), respectively.
- Compare the spectra to the certified values. Values should be within 5%.

7.5.2 Maintenance

- Lamps should be turned on and allowed to warm up at least 30 minutes before use.
- Lamps may need to be changed periodically. Refer to S.E.E. User's Manual Chapter 4.
- Clean dust on optics with a stream of dry, clean, nitrogen gas (canned air) when needed. A cloth may be used to clean the stage and computer screen.
- Clean filters using lens tissue (not Kimwipes) and methanol.

7.5.3 References

- "SEE2100 Microspectrometer User's Guide", S.E.E. Inc., Version V1.0, December 1999.
- "Grams/32 User's Guide", Galactic Industries Corp., V4.0, 1999.
- "NIST Traceable Filter Set Instruction Manual", S.E.E. Inc., Serial No. 128.

7.6 Gas Chromatograph-Mass Spectrometer

7.6.1 Performance Checks

The performance of the GC-MS should be checked each day a sequence is started using the Standard Autotune feature of the Chemstation software. The autotune uses PFTBA to optimize various parameters for the GCMS. The first step to a successful calibration is the GC-MS completing the autotune and printing the autotune report.

The analyst should complete the performance check by examining the autotune report to observe the peak shapes, to determine if there is a significant leak and to determine if any parameters indicate that the GC-MS is not in proper working condition.

If any m/z peaks below 69 m/z (e.g. 28 m/z , 32 m/z , or 40 m/z) are above 10% relative abundance to the 69 m/z , it is an indication of a significant leak the instrument is not in proper working condition and should be removed from service until it has been repaired and has passed the performance check.

The minimum parameters that the analyst should examine are Electron Multiplier (EM) Voltage and the repellor voltage. The normal ranges for the EM voltage vary from instrument to instrument, but the maximum voltage is 3000. If the autotune report shows an electron voltage of 2500 to 3000, the instrument should be removed from service until it has been repaired and has passed the performance check.

The repellor voltage also varies from instrument to instrument. The maximum repellor voltage for each instrument will be posted on the log sheet for that instrument. If the repellor voltage is at its maximum voltage, the analyst should remove the instrument from service until it has been repaired and has passed the performance check.

7.6.2 Maintenance

Routine maintenance:

The septa should be replaced before the next run after reaching 200 injections and injection liner should be replaced before the next run after reaching 400 injections. This should be recorded in the logbook.

Non-routine maintenance:

Other maintenance is performed on an as needed basis. When the GCMS has been removed from service to clean the source or replace the filaments, maintenance should be performed on the following items:

1. Source should be cleaned following Agilent/Hewlett Packard procedures.
2. Filaments should be replaced.
3. Diffusion pump oil should be inspected and replaced if necessary.
4. Rough pump oil should be checked and filled or replaced if necessary.

7.6.3 References

“HP 5973 Mass Selective Detector. Hardware Manual”, Hewlett Packard Company, P/N G1099-90027, November 1998.

“HP 6890 Series Gas Chromatograph Operating Manual”, Hewlett Packard Company, P/N G1530-90440, October 1996.

7.7 Chemicals and Reagents

7.7.1 *Quality Control*

- Chemicals and solvents used should be of a high quality.
- Chemicals should be labeled with analyst's initials and date when opened.
- Water used in reagent preparation should be either de-ionized or reverse osmosis.
- Reagents are prepared according to the directions found in the *Reagent Logbook*.
- Reagents are checked and documented in the logbook when prepared and each time they are used.
- The container with the prepared reagent should be labeled with the contents, analyst's initials, date prepared and expiration date.
- A bottle of reagent may continue to be used until it fails the quality check. If a reagent fails the quality check, immediately dispose of the remainder of the reagent.
- Any time a new chemical is received in the Trace Evidence Unit, an MSDS sheet should be obtained and placed in the binder containing the MSDS data sheets. A copy should also be given to the section safety manager.
- Any reagent used in non-routine examinations are prepared as needed, tested with knowns and blanks, and documented in the case file.
- Test strips are tested with standards and blanks.

7.7.2 *Storage*

- Chemicals and reagents should be stored in proper containers.
- Acids and bases should not be stored together.
- Flammables should be placed in one of the flammables cabinets.

8.0 PROFICIENCY TESTING PROGRAM

8.1 Proficiency Testing is performed according to the laboratory Quality Manual (Section 8).

8.1.1 Each trace evidence analyst must complete at least one proficiency test annually in a Trace Evidence sub-discipline in which they perform casework

8.1.2 Analysts in the Trace Evidence Unit are required to complete at least one proficiency test in each sub-discipline in which they are performing case work during each five year accreditation cycle.

9.0 CASE RECORDS

9.1 Documentation

The Trace Evidence Unit uses the documentation of case records set forth in the laboratory Quality Manual (Section 9).

The date the case is started is recorded in the notes or on the case worksheet. Dates of analysis are documented in the notes or on the documentation generated by the instrument. The ending date for work is considered the date recorded in Justice Trax as “Draft Completed”.

All instrument data that is not scanned into Justice Trax as part of the case record will be stored by case number on the instrument used. The data will then be backed up semi-annually and securely stored.

9.2 Release of Information

Information is released in accordance with the laboratory Quality Manual (Section 9.2.2)

9.3 Technical and Administrative Reviews

Reviews are conducted in accordance with the laboratory Quality Manual (Section 9.3)

10.0 TESTIMONY REVIEW

Testimony reviews will be conducted according to the guidelines in the laboratory Quality Manual (Section 10).

11.0 AUDITS

Audits for the section will be conducted according to guidelines in the laboratory Quality Manual (Section 11).

12.0 COMPLAINTS

Complaints will be handled in compliance with the overall Quality Manual for the Laboratory (Section 12).

13.0 SAFETY

All safety protocol and information is contained in a separate manual. This safety manual covers general laboratory safety.