Technical Procedure for the Analysis of Paints and Polymers

1.0 Purpose – This technical procedure shall be followed for the examination of paint and/or polymer evidence.

2.0 Scope – This procedure applies to Forensic Scientists performing paint and polymer examinations in the Trace Unit.

3.0 Definitions - N/A

4.0 Equipment, Materials, and Reagents

4.1 Equipment

- Stereomicroscope
- Polarizing light microscope
- Comparison microscope with Fluorescence
- Reflected light microscope
- Optivisor
- Micro Fourier Transform Infrared Spectrophotometer (FT-IR)
- Scanning Electron Microscope/Energy Dispersive X-Ray system (SEM/EDS)
- Pyrolysis Gas Chromatograph-Mass Spectrometer (Py-GC-MS)
- Microspectrophotometer
- Paint Database Query (PDQi) & Know-It-All Software
- PPG/DuPont Refinish Books
- Alternate Light Source (ALS)

4.2 Materials

- Razor blades
- Scalpel and blades
- KBr discs
- Microscope slides and cover slips
- Roller knife
- Dissecting needles
- Tweezers/Forceps
- Probes
- Spot Wells
- SEM stubs
- Pipette and bulbs
- Metal tins

4.3 Reagents

- Diphenylamine
- Chloroform
- Acetone

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5.0 Procedure

5.1 Analytical Approach

5.1.2 General Guidelines

5.1.1.1 The Forensic Scientist shall approach a paint comparison by attempting to show that the samples are different. The failure to detect any significant differences, after exhausting the methodology available to the Forensic Scientist, results in the conclusion that the known and questioned paints could have had a common origin.

5.1.1.2 The questioned and known paints are analyzed using the same techniques and are compared at every step throughout the process. If an unexplainable difference is found, the analysis may be concluded at any step.

5.1.1.2.1 The order of the examination is based on the quantity, quality, type of evidence and the Forensic Scientist's training and experience.

5.1.1.2.2 Some of the tests available to Forensic Scientists are destructive. When sample size is limited, destructive testing, if necessary, shall be performed only after all non-destructive testing is complete.

5.1.1.3 All results shall be based on the Forensic Scientist's knowledge and experience and the case being examined. Results shall be in agreement with the technical reviewer.

5.1.2 There are two distinct types of analyses requested of a paint examiner. The first is to compare an unknown paint sample to known paint samples. The second is a make/model determination. Each of these shall be addressed individually.

5.1.3 **Paint comparisons** – Comparing an unknown paint sample to a known standard.

5.1.3.1 Review the request for analysis.

5.1.3.2 Open the evidence container and describe the evidence present.

5.1.3.3 Conduct a preliminary, macroscopic examination of the paint evidence. The evidence is screened for paint and smears that appear to be macroscopically similar to the known paint standards. Those that appear macroscopically similar shall be collected and subjected to further analysis.

5.1.3.4 If necessary, the item shall be processed to remove any paint evidence adhering to the item following the Trace Unit Technical Procedure for the Collection and Preservation of Evidence.

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5.1.3.5 A physical match examination shall be conducted, if necessary, based on the Forensic Scientist's training and experience, according to the Trace Unit Technical Procedure for Physical Match Analysis.

5.1.3.6 Conduct a microscopic examination of the paint sample using a stereomicroscope, polarized microscope, reflected light microscope, and/or comparison microscope. The physical properties of the paint sample shall be noted (including layer structure, color, texture, thickness, and any other unusual features).

5.1.3.7 Collect samples of each individual layer for further analysis.

5.1.3.8 Acquire data for the comparison of each layer by utilizing the analytical techniques in **5.2**.

5.1.3.9 Compare the data, form a conclusion, and prepare a report.

5.1.4 Vehicle Make/Model Search

5.1.4.1 Review the request for analysis.

5.1.4.2 Open the evidence container and describe the evidence present.

5.1.4.3 If necessary, the item shall be processed to remove any paint evidence adhering to the item following the Trace Unit Technical Procedure for the Collection and Preservation of Evidence

5.1.4.4 Use a stereomicroscope or other appropriate magnifier to locate any paint chips on the evidence or in the debris collected from the evidence.

5.1.4.5 Conduct a microscopic examination of the paint to determine if there are any with an original equipment manufacturer (OEM) paint structure consisting of a topcoat and an undercoat.

5.1.4.6 Collect samples of each individual layer for further analysis.

5.1.4.7 Analyze each layer of the paint by FTIR and/or SEM/EDS according to the guidelines in **5.2**.

5.1.4.8 Information for each layer shall be entered into the PDQi/Know-It-All Software and a search conducted of the database.

5.1.4.9 Manufacturers' information and automotive refinish books (PPG/DuPont) may also be used in conjunction with PDQ results to limit make/model/year results.

5.1.4.10 The search results shall be reported as to the possible make, model and range of years in which the OEM sequence may have been used. A partial VIN may or may not be generated.

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5.2 Analytical Techniques

5.2.1 Guidelines

5.2.1.1 Physical comparisons shall be performed and documented using a minimum of two of the following:

5.2.1.1.1 Visual examination.

5.2.1.1.2 Stereomicroscopy.

5.2.1.1.3 Reflective light microscopy.

5.2.1.1.4 Polarized light microscopy.

5.2.1.1.5 Fluorescence examination.

5.2.1.2 Color comparison shall be performed using one of the following:

5.2.1.2.1 Comparison microscopy.

5.2.1.2.2 Microspectrophotometry, following the Trace Unit Technical Procedure for Microspectrophotometry.

5.2.1.3 Chemical comparison shall be performed and documented using the following methods. The Forensic Scientist shall choose the appropriate methods based on training and experience.

5.2.1.3.1 Solubility and Chemical Tests, following **5.2.2.**

5.2.1.3.2 FT-IR, following the Trace Unit Technical Procedure for Infrared Spectroscopy.

5.2.1.3.2.1 For extremely thin or contaminated smears, FT-IR may be the only instrumental analysis possible.

5.2.1.3.3 SEM/EDS, following the Trace Unit Technical Procedure for Scanning Electron Microscope/Energy Dispersive X-Ray System (SEM/EDX) for non-GSR Casework.

5.2.1.3.4 Py-GC-MS, following the Trace Unit Technical Procedure for Pyrolysis Gas Chromatography – Mass Spectroscopy.

5.2.2 Solubility and Chemical Testing

5.2.2.1 Diphenylamine spot test

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5.2.2.1.1 **Purpose** – A microchemical test to indicate the presence of oxidizing ions such as nitrates, nitrites, chlorates, and ferric ions. This includes nitrocellulose paints.

5.2.2.1.2 **Procedure**

5.2.2.1.2.1 Place the paint layer in the field of view of a stereomicroscope.

5.2.2.1.2.2 Apply the reagent directly to the layer.

5.2.2.1.2.3 Note any resulting reaction (including color change, color bleeding, bubbling, dissolving or no reaction).

5.2.2.1.2.4 The formation of a blue color is a positive reaction.

5.2.2.1.2.5 Carbonate compounds will bubble due to the reaction with the sulfuric acid in the Diphenylamine reagent.

5.2.2.1.2.6 The procedure shall be repeated for each layer in the known and questioned paint samples. The results shall then be compared.

5.2.2.1.3 **Standards and Controls** – The spot test solution must be tested with a known nitrate with each case in which the test is utilized.

5.2.2.2 **Chloroform**

5.2.2.2.1 **Purpose** – A microsolubility test to indicate the presence of acrylic lacquers.

5.2.2.2.2 **Procedure**

5.2.2.2.2.1 Place the paint layer in the field of view of a stereomicroscope.

5.2.2.2.2.2 Apply the solvent directly to the layer.

5.2.2.2.2.3 Note any resulting reaction (including color change, color bleeding, bubbling, dissolving or no reaction).

5.2.2.2.2.4 Only an acrylic lacquer will dissolve in chloroform. Nitrocellulose lacquers and enamels do not dissolve in chloroform.

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5.2.2.2.2.5 Latex paints will soften and become tacky in chloroform.

5.2.2.3 Acetone

5.2.2.3.1 **Purpose** – A microsolubility test to indicate the presence of acrylic lacquers and nitrocellulose lacquers.

5.2.2.3.2 Procedure

5.2.2.3.2.1 Place the paint layer in the field of view of a stereomicroscope.

5.2.2.3.2.2 Apply the solvent directly to the layer.

5.2.2.3.2.3 Note any resulting reaction (including color change, color bleeding, bubbling, dissolving or no reaction).

5.2.2.3.2.4 Acrylic lacquers and nitrocellulose lacquers will dissolve in acetone. Enamels do not dissolve in acetone.

5.2.2.3.2.5 Latex paints will soften and become tacky in acetone.

5.3 Guidelines for Paint or Polymer Analysis Result and Conclusion Statements

5.3.1 The reports shall read as listed below. The wording of the results shall accurately describe the evidence at hand.

5.3.2 Paint Comparisons

5.3.2.1 Positive

5.3.2.1.1 This statement shall be used when the questioned and known samples are consistent in color, layer structure and chemical composition.

5.3.2.1.1.1 Example: Examination of Item A revealed a paint chip with the following layer structure: ___/___/___/___. The paint recovered from Item A was found to be physically and chemically consistent with paint from Item B. Therefore, the paint from Item A could have originated from [the same source as the paint in] Item B.

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5.3.2.1.2 Qualifying Statements

5.3.2.1.2.1 A Qualifying Statement may be added to the report if the questioned paint is consistent with the known standard and is so complex or unusual in its physical and chemical properties that it is highly unlikely that it could have come from any other source.

5.3.2.1.2.1.1 Example: It is highly unlikely that the paint from Item A originated from a source other than [the source of] Item B.

5.3.2.1.2.2 Qualifying statements may also be added to the report if limited testing was performed or if the samples lacked comparable characteristics.

5.3.2.2 Inconclusive

5.3.2.2.1 Questioned and known paints exhibit similarities in characteristics, but slight differences were noted.

5.3.2.2.1.1 Example: Examination of the paint from Item A found it to be physically / chemically similar to the paint from Item B. However, slight differences were noted. Therefore, no conclusion could be reached as to whether or not the paint in Item A could have originated from [the same source as] Item B.

5.3.2.2.2 Qualifying statements may also be added to the report when things such as on-scene sampling or the condition of the evidence could be the cause of the noted differences.

5.3.2.2.2.1 Example: Due to the size or condition of the paint in Item A, no conclusions could be reached as to whether or not it could have originated from [the same source as the paint in] Item B.

5.3.2.3 Negative

5.3.2.3.1 This statement is used when one or more of the characteristics associated with the questioned and known paints are different.

5.3.2.3.1.1 Example: Paint from Item A is not consistent with than paint from Item B. Therefore, the paint from Item A could not have originated from [the same source as the paint in] Item B.

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5.3.2.4 No associations or No paint found

5.3.2.4.1 Example: No paint associations were found between Item A and Item B.

5.3.2.4.2 Example: No paint of value was found for a comparison (e.g., not the appropriate color).

5.3.2.4.3 Example: No (automotive) paint was found on the questioned item.

5.3.2.5 No Analysis

5.3.2.5.1 No analysis is performed due to the results of the DNA analysis.

5.3.2.5.1.1 Example: Based on the results of DNA analysis, the above listed evidence is being returned unanalyzed. If you have any questions, please contact the Forensic Scientist who issued this report.

5.3.2.5.2 Based on the analysis of one or more other items, the remaining items will not be analyzed.

5.3.2.5.2.1 Example: Based upon the above results, Items A and B were not analyzed.

5.3.2.5.2.2 Example: Based upon the above results, no further analysis was conducted on Item A.

5.3.2.5.3 Due to the condition of the sample, no analysis was conducted.

5.3.2.5.3.1 Example: Due to the size or condition of the questioned paint sample, no analysis was conducted.

5.3.3 Make/Model Searches

5.3.3.1 Unsuitable

5.3.3.1.1 Example: The paint chips located in the clothing were not suitable for entry into the database. However, Item(s) ___ may be resubmitted along with the appropriate standards should a suspect vehicle be located.

5.3.3.1.2 Example: No (automotive) paint was found on the questioned item.

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5.3.3.2 Successful

5.3.3.2.1 Example: A search of the PDQ database indicated that the paint chip from Item A was consistent with paint used on the following vehicles: (list vehicles). (List potential VIN). It should be noted that not all makes/models/years of vehicles produced by each manufacturer are present in the database and that no vehicle with the appropriate damage should be excluded based upon the above listed information.

5.3.3.3 Unsuccessful

5.3.3.3.1 Example: The chemical characteristics of the paint chip that were entered into the database did not reveal information regarding vehicle make, model, plant of manufacture, and year of manufacture.

5.4 Standards and Controls – All required standards and controls are detailed in the individual sections above, as applicable.

5.5 Calibrations – This procedure does not require any calibrations. However, it does utilize instruments that require calibration. See the individual technical procedures for the operations of those instruments.

5.6 Maintenance – No maintenance is required in this procedure. However, the procedure does utilize instruments that require maintenance. See the individual technical procedures for the operations of those instruments.

5.7 Sampling and Sample Selection

5.7.1 No sampling is performed. When sample selection occurs, it shall be based on the Forensic Scientist's training and experience.

5.7.2 Samples shall be chosen for analysis based on the quality of the sample. Complete paint chips are analyzed first, followed by incomplete chips, followed by smears.

5.7.3 If two or more smears/chips appear macroscopically consistent with each other, analysis is performed on one of the smears/chips. If the smear/chip is found to be consistent with the known standard, the analysis may stop. If it is not, then analysis shall continue on another sample until either one is found to be consistent with the known sample or there are no remaining samples to analyze.

5.7.4 In cases where there is more than one item of the victim's clothing submitted (e.g., hit and run), the Forensic Scientist shall analyze the article of clothing that has the paint evidence with the most complete layer structure first. If the paint is found to be consistent with the known, no additional items of clothing shall be analyzed.

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5.7.5 If the evidence appears to have been potentially contaminated (e.g., loose paint chips in the main mailing envelope where the known standards and questioned samples are in the same outer envelope), the evidence shall be returned unworked.

5.7.6 If nuclear DNA has been performed on the evidence in the case and the results of the DNA analysis conclusively link the victim and the suspect (vehicle/item), the paint evidence may be returned unworked.

5.7.7 If it is not a PDQ case, and no proper standards were submitted, the evidence shall be returned unworked.

5.8 Calculations – N/A

5.9 Uncertainty of Measurement – N/A

6.0 Limitations

6.1 Paint is a manufactured material. Therefore, paint cannot be identified to the exclusion of all other paints.

6.2 Vehicles are manufactured and painted on paint lines. Therefore, in most cases, they cannot be identified to the exclusion of all other vehicles painted on the same factory paint line.

6.3 Paint smears are often mixtures. Great care shall be employed when interpreting the results of the comparison of paint smears with paint chips.

7.0 Safety

7.1 Concentrated acids and solvents shall be used in a well-ventilated area with proper precautions being exercised to minimize skin contact.

7.2 Items with paint evidence may be bulky, heavy, and/or may have sharp edges. Exercise care when handling these items.

7.3 Victim's clothing and other items may have blood or other body fluids present. Use protective equipment when dealing with items that may contain biohazard material.

8.0 References

8.1 ASTM / SWG Guidelines

ASTM Standard E 1610-02(2008), "Standard Guide for Forensic Paint Analysis and Comparison." ASTM International, West Conshohocken, PA, 2008.

Scientific Working Group for Materials Analysis (SWGMAT), "Forensic Paint Examination and Comparison Guidelines." *Forensic Science Communications* 1.2 (July 1999).

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8.2 Books

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Crown, D.A. *The Forensic Examination of Paints and Pigments.* Springfield: C.C. Thomas, 1986.

Saferstein, R., ed. *Forensic Science Handbook.* Volume I. 2nd edition. Englewood Cliffs: Prentice Hall Regents, 2002. Chapter 8: Forensic Paint Examination

8.3 Journal Articles

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Rodgers, P.G., et al. "The Classification of Automobile Paint by Diamond Window Infrared Spectroscopy, Part I: Binders and Pigments." *Canadian Society of Forensic Science Journal* 9.1 (1976): 1-14.

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Thornton, J.I., et.al. "Solubility characterization of Automotive Paints." *Journal of Forensic Sciences* 28.4 (1983): 1004-1007.

8.4 Training Materials

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Ryland, S.G., "Forensic Paint Examinations and Comparisons" workshop held in Columbia, SC October 6-10, 2010.

Ryland, S., "Paint Binder Classification by Infrared Spectrometry and Pyrolysis Gas Chromatography." SAFS workshop, Spring 1991.

9.0 Records – N/A

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10.0 Attachments – N/A

Revision History		
Effective Date	Version Number	Reason
09/17/2012	1	Original ISO Document
10/18/2013	2	Added issuing authority to header
08/29/2014	3	Updated header to Physical Evidence Section – Trace Unit, issuing authority to Physical Evidence Section Forensic Scientist Manager. Updated all references in procedure from Trace Evidence Section to Trace Unit 4.1 - Added Fluorescence and Alternate Light Source Changed wording in 5.1.4.7 4.1 and 5.1.4.8 - Updated PDQ software information Corrected grammar

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