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An American National Standard

Standard Practice for Forensic Paint Analysis Training Program[1]

This standard is issued under the fixed designation E3234; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This document is intended as a practice for use by laboratory personnel responsible for training examiners to perform forensic examinations and comparisons of paint. It contains a list of training objectives with recommended methods of instruction, reading assignments and structured exercises to provide practical experience for the trainee.

1.1.1 The trainees and training program shall meet or exceed the minimum training requirements set forth in Practice E2917.

1.1.2 Additional training could be required for a particular method or instrument referred to herein. The application of analytical techniques to paint analysis assumes the trainee is already competent in the use of each particular analytical technique or instrumental method.

1.1.3 Other sources of information on forensic paint examination not specifically mentioned in this document can be considered and added.

1.1.4 Additional paint analysis training beyond that which is listed here should be made available to the trainee. Such training could include off-site courses, internships, and specialized training by experienced examiners.

1.1.5 Continuing education and training is recommended. Additional training provides a forensic paint examiner with the opportunity to remain current in the field.

1.1.6 Paint samples occasionally are evaluated for physical matches of broken edges. This document does not provide training requirements for physical match comparisons. Additional training is required to conduct this type of analysis.

1.2 This practice is in a modular format for easy adaptation to an individual laboratory's training program. Recommendations as to lessons, practical exercises, progress monitoring, and trainee evaluations are included. Reading assignments are listed in each subsequent section of this practice; full citations are available in the References section.

1.3 A paint analysis training program provides a theoretical foundation and basic practical skills necessary to prepare a trainee to become a qualified forensic paint examiner. At the end of the paint analysis training program, the trainee is capable of forming opinions based upon sound scientific knowledge, appropriate examinations, and practical experience. The trainee also is able to independently work cases, write reports, testify in court, and peer review cases. Upon completion of the program by a trainee or at some regular interval (for example, once per accreditation cycle), the training program should be evaluated for its efficacy and relevance according to the guidance set forth in Practice E2917.

1.4 This standard practice does not address human factors (for example, cognitive bias). It is the responsibility of the user of this standard to address human factors during the initial or general training of a forensic scientist. Refer to Practice E2917.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

E2917 Practice for Forensic Science Practitioner Training, Continuing Education, and Professional Development Programs

D16 Terminology for Paint, Related Coatings, Materials, and Applications

D1535 Practice for Specifying Color by the Munsell System

D4764 Test Method for Determination by X-ray Fluorescence Spectroscopy of Titanium Dioxide Content in Paint

D5380 Test Method for Identification of Crystalline Pigments and Extenders in Paint by X-Ray Diffraction Analysis

[1] This practice is under the jurisdiction of ASTM Committee E30 on Forensic Sciences and is the direct responsibility of Subcommittee E30.01 on Criminalistics.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

D5381 Guide for X-Ray Fluorescence (XRF) Spectroscopy of Pigments and Extenders
E308 Practice for Computing the Colors of Objects by Using the CIE System
E1459 Guide for Physical Evidence Labeling and Related Documentation
E1492 Practice for Receiving, Documenting, Storing, and Retrieving Evidence in a Forensic Science Laboratory
E1610 Guide for Forensic Paint Analysis and Comparison
E2808 Guide for Microspectrophotometry in Forensic Paint Analysis
E2809 Guide for Using Scanning Electron Microscopy/Energy Dispersive X-Ray Spectroscopy (SEM/EDS) in Forensic Polymer Examinations
E2937 Guide for Using Infrared Spectroscopy in Forensic Paint Examinations

3. Significance and Use

3.1 The procedures outlined herein are grounded in the generally accepted body of knowledge and experience in the field of forensic paint examination and comparison.

3.2 With successful completion of this paint analysis training program, the trainee gains the theoretical knowledge and practical skills necessary to perform, document, and evaluate forensic paint examinations and comparisons.

3.3 This training practice covers a variety of instrumental methods which can be used in the analysis of paint. Not all laboratories will have access to all of the instrumentation. It is expected that a paint analysis training program will include all the techniques that are found within a laboratory's procedures for the forensic examination of paint.

3.3.1 Instrumental methods that provide organic and inorganic analysis capabilities are utilized in the laboratory training program. Examples include Fourier transform infrared spectroscopy (FTIR), Raman spectroscopy, pyrolysis gas chromatography (PGC), scanning electron microscopy-energy dispersive X-ray spectroscopy (SEM/EDS), X-ray fluorescence (XRF), and X-ray diffraction (XRD).

4. Responsibilities

4.1 Each trainee is trained by and works under the guidance of, one or more qualified forensic paint examiners.

4.1.1 The trainee shall meet or exceed the minimum training criteria set forth in Practice E2917 and the objectives set forth in the training program.

4.2 A trainer shall be technically qualified in forensic paint examination and comparison or associated techniques. Other members of the laboratory are encouraged to offer relevant information regarding their specialty to the trainee. The trainer(s) is responsible for:

4.2.1 Introducing the trainee to the relevant scientific literature, appropriate procedures, training material, and reference collections.

4.2.2 Discussing readings and theory with the trainee.

4.2.3 Teaching basic microscopy and instrumental methods for the analysis and comparison of paint evidence.

4.2.4 Teaching case management.

4.2.5 Fostering ethical professional conduct.

4.2.6 Reviewing ways in which bias can influence paint examinations.

4.2.7 Teaching appropriate quality assurance and quality control procedures.

4.2.8 Reviewing tests, practical exercises, and casework samples with the trainee.

4.2.9 Teaching expert testimony skills through moot court or observation, or both.

4.2.10 Monitoring the trainee's progress

4.3 Each laboratory is required to maintain:

4.3.1 An up-to-date training program which is reviewed and assessed for efficacy and relevance as described in Practice E2917.

4.3.2 Documentation of training according to Practice E2917.

4.3.3 Documentation of competency tests and proficiency tests.

5. Syllabus

5.1 A paint analysis training program provides the trainee theoretical knowledge and practical skills in examining, interpreting, reporting, testifying, and reviewing forensic paint cases. This is accomplished through a combination of the following training methods:

5.1.1 *Reading of Relevant Literature:*

5.1.1.1 The reading assignments listed are suggestions. Newer versions can be used. Other relevant literature can be used or substituted.

5.1.2 *Instruction and Observation of Forensic Paint Examiners:*

5.1.2.1 Lectures and discussions,

5.1.2.2 Practical demonstration of basic skills,

5.1.2.3 Casework, and

5.1.2.4 Court testimony.

5.1.3 *Practical Skills:*

5.1.3.1 Practical exercises which includes analysis of reference materials and known samples.

5.1.4 *Final Competency Evaluations:*

5.1.4.1 Written or oral tests,

5.1.4.2 Practical laboratory tests,

5.1.4.3 Mock cases, and

5.1.4.4 Moot court or oral exam.

5.1.5 *Performing Supervised Casework.*

5.2 The recommended training period is between three to six months, full time, for a forensic examiner that has been previously trained and is competent in the analytical techniques utilized in the analysis of paint evidence. For new examiners with no previous training in microscopical or instrumental techniques, the expected training period is between twelve to eighteen months.

5.3 Successful completion of each milestone in the training program will be recorded using the guidance set forth in Practice E2917.

6. Paint Analysis Training Program Objectives

6.1 *Encountering Paint Evidence:*

6.1.1 This section introduces the trainee to the types of cases and the various conditions in which paints are encountered as physical evidence.

6.1.2 Types of paints which could be encountered as evidence include automotive paint, other vehicle paint (for example, motorcycle, aircraft, marine, trains, bicycle.), architectural paint, maintenance paint, spray paint, and other specialty paints.

6.1.3 *Reading Assignments:*

6.1.3.1 Ryland, "Infrared Microspectroscopy of Forensic Paint Evidence," pp. 163–170 and pp. 185–191 (**1**).[3]

6.1.4 *Practical Exercises:*

6.1.4.1 Demonstrate knowledge of the types of cases and the various conditions in which paints are encountered as physical evidence through an oral or written exercise.

6.1.5 The methods of instruction for this unit are reading and research by the trainee and discussions with the trainer(s).

6.1.6 The method of evaluation for this unit is a review of the trainee's completed exercise by the trainer.

6.2 *Paint Terminology:*

6.2.1 This section introduces the trainee to the following terms:

6.2.1.1 Additives,
6.2.1.2 Binder (resin),
6.2.1.3 Coating,
6.2.1.4 Cross-linker,
6.2.1.5 Drier,
6.2.1.6 Drying oils,
6.2.1.7 Enamel,
6.2.1.8 Extender,
6.2.1.9 Lacquer,
6.2.1.10 Latex,
6.2.1.11 Paint,
6.2.1.12 Pigment,
6.2.1.13 Plasticizer,
6.2.1.14 Solvent,
6.2.1.15 Stain,
6.2.1.16 Thermoplastic polymer,
6.2.1.17 Thermosetting polymer,
6.2.1.18 Varnish, and
6.2.1.19 Vehicle.

6.2.2 *Reading Assignments:*

6.2.2.1 Lambourne, "Paint Composition and Applications – A General Introduction" (**2**).

6.2.2.2 Koleske, ed., *Paint and Coating Testing Manual* (**3**).

6.2.3 *Practical Exercises:*

6.2.3.1 Define the terms listed in this section.

6.2.4 The methods of instruction for this unit are reading and research by the trainee.

6.2.5 The method of evaluation for this unit is an oral or written quiz.

6.3 *The Use and Composition of Paint:*

6.3.1 This section introduces the trainee to the uses and compositions of different types of paints to include the following:

6.3.1.1 The significance of oils, driers, solvents, plasticizers, resinous vehicles, extenders, and pigments in the formation of paint films, examples of materials used in each of these components, and the differences between a liquid paint and a dried paint film in terms of each of these components.

6.3.1.2 The manner in which latex, thermoplastic and thermosetting paint films are formed.

6.3.1.3 The impact of the film formation mechanism on a forensic paint examination.

6.3.1.4 Various types of paint to end-use applications.

6.3.1.5 Additives used in latex paints.

6.3.2 *Reading Assignment:*

6.3.2.1 Morgans, *Outlines of Paint Technology* (**4**).

6.3.3 *Practical Exercise:*

6.3.3.1 Explain the uses and differences of the paint components listed in this section.

6.3.4 The methods of instruction for this unit are reading and research by the trainee.

6.3.5 The method of evaluation for this unit is an oral or written quiz.

6.4 *Manufacturing Processes:*

6.4.1 This section introduces the trainee to paint manufacturing and application processes to include the following:

6.4.1.1 How raw materials are acquired and mixed.

6.4.1.2 What variations could be present in raw materials.

6.4.1.3 What variations could exist in binders from different companies.

6.4.1.4 What a batch of paint is and typically how large it is.

6.4.1.5 What quality control procedures are used in the manufacture of paint.

6.4.1.6 How paint is packaged and distributed.

6.4.1.7 Application processes for non-motor vehicle paints (for example, brush, spray, powder coating, coil-coating).

6.4.1.8 The application process of original equipment manufacturer (OEM) finishes to motor vehicles.

6.4.1.9 Processes used in repainting and repairing vehicles.

6.4.1.10 The purposes of each motor vehicle finish layer.

6.4.1.11 Differences between OEM and repainted motor vehicle finishes.

6.4.1.12 Analytical and physical testing methods used by the paint industry.

6.4.2 *Reading Assignments:*

6.4.2.1 Bentley, "Composition, Manufacture and Use of Paint" (**5**).

6.4.2.2 Farkas, "The Industrial Paint-Making Process" (**6**).

6.4.2.3 Ryer, "Alkyd Chemistry and New Technology Trends in Coatings Resin Synthesis" (**7**).

6.4.2.4 Ryntz, "Automotive Coatings: Current Trends for Coating Plastic – Part 1" (**8**).

6.4.2.5 Wright and Mehltretter, "The Prevalence of Original Equipment Manufacturer (OEM) Factory Repairs in Automotive Paint Samples" (**9**).

6.4.3 *Practical Exercises:*

6.4.3.1 Explain the manufacturing and application processes of paint.

6.4.3.2 Visit paint manufacturing facilities when practical.

6.4.4 The method of instruction for this unit is reading by the trainee.

[3] The boldface numbers in parentheses refer to a list of references at the end of this standard.

6.4.5 The method of evaluation for this unit is an oral or written quiz.

6.5 *Overview of Forensic Paint Examinations:*

6.5.1 This section introduces the trainee to the basic steps in forensic paint examinations and how these steps are used to identify the components of a paint film.

6.5.2 *Reading Assignments:*

6.5.2.1 Laboratory specific paint analysis procedure(s)

6.5.2.2 Scientific Working Group for Materials Analysis (SWGMAT), "Trace Evidence Recovery Guidelines" (**10**).

6.5.2.3 Guide E1610.

6.5.2.4 Ryland, "Infrared Microscopy of Forensic Paint Evidence" (**11**).

6.5.2.5 Ryland, et al., "Current Trends in Forensic Paint Examination" (**12**).

6.5.2.6 Stoecklein, "Forensic Analysis of Automotive Paints at the Bundeskriminalamt: The Evidential Value of Automotive Paints" (**13**).

6.5.3 *Practical Exercises*—None.

6.5.4 The methods of instruction for this unit are reading by the trainee and lecture from the trainer.

6.5.5 The method of evaluation for this unit is an oral or written quiz.

6.6 *Search, Collection and Preservation Techniques for Paint Evidence:*

6.6.1 This section introduces the trainee to methods for locating, collecting, and preserving all types of paint evidence. The trainee is exposed to evidence handling issues such as transfer, persistence, and loss of trace evidence. Topics include the following:

6.6.1.1 The recognition of paint fragments and paint smears.

6.6.1.2 The use of visual examinations and low power magnification.

6.6.1.3 The use of the particle picking and scraping methods to collect loose debris.

6.6.1.4 Understanding the persistence, transfer, and loss of paint evidence.

6.6.1.5 Preservation techniques appropriate for various types of paint evidence.

6.6.2 *Reading Assignments:*

6.6.2.1 Guide E1459.

6.6.2.2 Practice E1492.

6.6.2.3 Guide E1610.

6.6.2.4 Palenik, "Microscopy and Microchemistry of Physical Evidence" (**14**).

6.6.2.5 Pearson, et al., "Glass and Paint Fragments Found in Men's Outer Clothing – Report of a Survey" (**15**).

6.6.2.6 SWGMAT, "Trace Evidence Recovery Guidelines" (**10**).

6.6.2.7 SWGMAT, "Trace Evidence Quality Assurance Guidelines" (**16**).

6.6.3 *Practical Exercises:*

6.6.3.1 Perform collections from several paint samples to include paint fragments, paint smears and high impact transfers from a variety of materials utilizing the methods learned above.

6.6.3.2 Demonstrate appropriate packaging techniques for debris collected and items of evidence.

6.6.4 The methods of instruction for this unit are reading by the trainee and practical instruction from the trainer.

6.6.5 The method of evaluation for this unit is an evaluation of the practical exercises.

6.7 *Recognition, Description and Categorization of Paint:*

6.7.1 This section introduces the trainee to the recognition, description, and categorization of paint by:

6.7.1.1 Recognizing paint utilizing microscopical techniques including stereomicroscopy.

6.7.1.2 Describing paint layers in terms of color, layer sequence, layer thickness, gloss, and texture.

6.7.1.3 Recognizing after-market treatments, surface defects, weathering, aging, contaminants, damage, and intra/interlayer features.

6.7.1.4 Categorizing paint as automotive, other vehicle (for example, motorcycle, aircraft, marine, trains, bicycle.), architectural, maintenance, spray, or other specialty types.

6.7.1.5 Categorizing automotive OEM finishes and automotive repaints by their layer structures. This includes the recognition of spot putties, body fillers, color coordinated primers, monocoats, and tri-coat systems.

6.7.1.6 Recognizing various types of pigments and extenders (for example, metal flake, pearlescent, interference, effect, hiding).

6.7.2 *Reading Assignments:*

6.7.2.1 Boudreau and Cortner, "Application of Differential Interference Contrast Microscopy to the Examination of Paints" (**17**).

6.7.2.2 Govaert and Bernard, "Discriminating Red Spray Paints by Optical Microscopy, Fourier Transform Infrared Spectroscopy, and X-ray Fluorescence" (**18**).

6.7.2.3 Hamer, "Pigment Analysis in the Forensic Examination of Paints III: A Guide to Motor Vehicle Paint Examination by Transmitted Light Microscopy" (**19**).

6.7.2.4 Iden, "Teamwork Brings Innovative Effect Pigment to Light" (**20**).

6.7.2.5 Kilbourn and Marx, "Polarized Light Microscopy of Extenders in Structural Paints – Forensic Applications" (**21**).

6.7.2.6 Koleske, ed., *Paint and Coating Testing Manual* (**3**).

6.7.2.7 McNorton, et al., "The Characterization of Automotive Body Fillers" (**22**).

6.7.2.8 Novinski, et al., "Employing Pearlescent Pigments in High Performance Coatings" (**23**).

6.7.2.9 Orzechowski, "An Optical Microscopy Method to Display Pigment Agglomerates in Polymer Particles" (**24**).

6.7.2.10 Streitberger and Dossel, K., eds., *Automotive Paints and Coatings* (**25**).

6.7.2.11 Walsh, et al., "New Zealand Body Fillers: Discrimination Using IR Spectroscopy, Visible Microspectrophotometry, Density and SEM-EDAX" (**26**).

6.7.3 *Practical Exercise:*

6.7.3.1 Describe and categorize a set of paint samples. Samples should consist of a variety of paint systems including automotive paint, other vehicle paint (for example, motorcycle, aircraft, marine, trains, bicycle.), architectural paint, maintenance paint, spray paint, and other specialty paints. Automotive systems with color coordinated primers, tri-coat systems and a variety of effect pigments should also be included.

6.7.4 The methods of instruction for this unit are reading by the trainee and practical instruction from the trainer.

6.7.5 The method of evaluation for this unit is an evaluation of the practical exercise.

6.8 *Color Assessments of Paint:*

6.8.1 This section introduces the trainee to the techniques used in the color assessments of paint including:

6.8.1.1 Understanding the definition of color.

6.8.1.2 Performing color comparisons using the unaided eye as well as the stereomicroscope and higher powered microscopes.

6.8.1.3 Understanding metamerism and the usage of various light sources in the evaluation and comparison of color

6.8.1.4 Demonstrating knowledge of the various systems available to assess color, measure color and perform color comparisons of paint samples (for example, the Munsell System, L*a*b* color space, and the CIE System).

6.8.1.5 Determining standard values for paint colors.

6.8.1.6 Demonstrating familiarity with the use of various spectrophotometers used to measure color samples.

6.8.2 *Reading Assignments:*

6.8.2.1 Cartwright, et al., "The Classification of Automotive Paint Primers Using the Munsell Color Coordinate System – A Collaborative Study" (**27**).

6.8.2.2 Droll, "Just What Color is That Car?" (**28**).

6.8.2.3 The Munsell Book of Color Glossy Collection.

6.8.2.4 The Munsell Book of Color Matte Collection.

6.8.2.5 Thornton, "Visual Color Comparison in Forensic Science" (**29**).

6.8.3 *Practical Exercise:*

6.8.3.1 Demonstrate the ability to utilize available resources (for example, Munsell System, L*a*b* color space, CIE System) to determine standard color values for a given set of paint samples

6.8.4 The methods of instruction for this unit are reading by the trainee and lecture from the trainer.

6.8.5 The method of evaluation for this unit is a review of the practical exercise.

6.9 *Sample Preparation Techniques:*

6.9.1 This section introduces the trainee to the sample preparation techniques used in paint analysis including:

6.9.1.1 Performing manual manipulation of a paint fragment with a scalpel or other cutting tool to expose underlying layers.

6.9.1.2 Preparing samples of individual layers for transmitted and reflected light microscopical examinations.

6.9.1.3 Preparing thin cross-sections of several paint fragments.

6.9.2 *Reading Assignments:*

6.9.2.1 Allen, "Modifications of Sample Mounting Procedures and Microtome Equipment for Paint Sectioning" (**30**).

6.9.2.2 Derrick, "Infrared Microspectroscopy in the Analysis of Cultural Artifact" (**31**).

6.9.2.3 Laing, et al., "The Examination of Paint Films and Fibers as Thin Sections" (**32**).

6.9.3 *Practical Exercises:*

6.9.3.1 Expose layers of several paint fragments using various cutting techniques (for example, bevel (wedge), stair step, thin peels, and cross-sections.)

6.9.3.2 Prepare microscope slides of individual layers from a paint sample.

6.9.3.3 Prepare thin cross-sections of several samples provided by the trainer.

6.9.4 The methods of instruction for this unit are reading by the trainee and practical instruction from the trainer.

6.9.5 The method of evaluation for this unit is an evaluation of the practical exercises.

6.10 *Microscopical Examination and Comparison:*

6.10.1 This section introduces the trainee to the microscopical examination and comparison of paint including:

6.10.1.1 Using stereomicroscopy and comparison microscopy to determine whether paint samples are distinguishable from one another.

6.10.1.2 Examining paint samples utilizing other microscopical techniques which may include polarized light and fluorescence microscopy.

6.10.1.3 Recognizing the microscopical characteristics of pigments, extenders, and additives.

6.10.2 *Reading Assignments:*

6.10.2.1 Delly, et al., *Polarized Light Microscopy* (**33**).

6.10.2.2 DeForest, "Foundations of Forensic Microscopy" (**34**).

6.10.3 *Practical Exercise:*

6.10.3.1 Examine and compare several samples provided by the trainer and determine whether any items within a set can be distinguished from the others

6.10.4 The methods of instruction for this unit are reading by the trainee and practical instruction from the trainer.

6.10.5 The method of evaluation for this unit is an evaluation of the practical exercise.

6.11 *Microchemical Examinations:*

6.11.1 This section introduces the trainee to classifying paint binders, pigments and extenders by use of microchemical examinations to include:

6.11.1.1 Using solvent tests to correctly classify an automotive paint layer in terms of enamel, acrylic lacquer, nitrocellulose lacquer, solution lacquer, or dispersion lacquer.

6.11.1.2 Using solvent tests to correctly classify automotive paints as OEM or repaint (if possible).

6.11.1.3 Using solvent tests to correctly classify non-automotive paints in terms of enamel or lacquer.

6.11.1.4 Using microchemical testing to classify pigments and extenders.

6.11.2 *Reading Assignments:*

6.11.2.1 Palenik, S., "Applying Chemical Microscopy to the Coatings Industry" (**35**).

6.11.2.2 Thornton, et al., "Solubility Characterization of Automotive Paints" (**36**).

6.11.2.3 Ryland, "Infrared Microscopy of Forensic Paint Evidence" (**11**).

6.11.2.4 Beattie, et al., "The Use of Morin Staining for the Microscopic Characterization of Multilayered White Paint Flakes" (**37**).

6.11.2.5 Linde and Stone, "Application of the LeRosen Test to Paint Analysis" (**38**).

6.11.2.6 Home, et al., "The Discrimination of Small Fragments of Household Gloss Paint Using Chemical Tests" (**39**).

6.11.3 *Practical Exercise:*

6.11.3.1 Classify several paint samples using microchemical tests.

6.11.4 The methods of instruction for this unit are reading by the trainee and practical instruction from the trainer.

6.11.5 The method of evaluation for this unit is an evaluation of the practical exercise.

6.12 *Fourier Transform Infrared Spectroscopy (FTIR):*

6.12.1 This section introduces the trainee to the classification and comparison of a variety of paint binders, pigments, extenders and additives based on their chemical composition using FTIR.

6.12.2 Include the following points of instruction:

6.12.2.1 Understanding the theory of FTIR analysis (unless previously authorized to use the instrument).

6.12.2.2 Preparing samples for analysis by FTIR.

6.12.2.3 Performing computer searches of spectral libraries, if available.

6.12.2.4 Using FTIR to classify and compare binders, pigments, and extenders found in automotive, architectural, and other types of paint.

6.12.2.5 Understanding the strengths and limitations of the technique.

6.12.3 *Reading Assignments:*

6.12.3.1 McEwen, and Cheever, "Infrared Microscopic Analysis of Multiple Layers of Automotive Paints" (**40**).

6.12.3.2 Home, et al., "The Characterization of Automotive Body Fillers" (**41**).

6.12.3.3 Norman, et al., "The Classification of Automotive Paint Primers Using Infrared Spectroscopy – A Collaborative Study," (**42**).

6.12.3.4 Ryland, "Infrared Microspectroscopy of Forensic Paint Evidence," pp. 163–243 (**1**).

6.12.3.5 Wilkinson, et al., "The Examination of Paints as Thin Sections Using Visible Microspectrophotometry and Fourier Transform Infrared Microscopy" (**43**).

6.12.4 *Practical Exercises:*

6.12.4.1 Prepare and analyze several single layer and multiple layered structural and automotive paint samples having a variety of binder types, pigments, extenders and additives.

6.12.4.2 Search several spectra against a spectral library.

6.12.4.3 Perform binder, pigment, extender and additive classifications and comparisons for the spectra of several unknown samples.

6.12.5 The methods of instruction for this unit are reading by the trainee and lectures and demonstrations from the trainer.

6.12.6 The method of evaluation for this unit is an evaluation of the practical exercises.

6.13 *Raman Spectroscopy:*

6.13.1 This section introduces the trainee to the comparison of a variety of paint components based on their chemical composition using Raman spectroscopy.

6.13.2 Include the following points of instruction:

6.13.2.1 Understanding the theory of Raman spectroscopy (unless previously authorized to use the instrument).

6.13.2.2 Preparing samples for analysis by Raman spectroscopy.

6.13.2.3 Performing computer searches of spectral libraries, if available.

6.13.2.4 Using Raman to classify and compare binders, pigments, and extenders found in automotive, architectural, and other types of paint.

6.13.2.5 Understanding the strengths and limitations of the technique.

6.13.3 *Reading Assignments:*

6.13.3.1 Bell, et al., "Forensic Analysis of Architectural Finishes Using Fourier Transform Infrared and Raman Spectroscopy, Part I: The Resin Bases" (**44**).

6.13.3.2 Bell, et al., "Forensic Analysis of Architectural Finishes Using Fourier Transform Infrared and Raman Spectroscopy, Part II: White Paint" (**45**).

6.13.3.3 Buzzini and Massonnet, "A Market Study of Green Spray Paints by Fourier Transform Infrared (FT-IR) and Raman Spectrometry" (**46**).

6.13.3.4 Kuptsov, "Applications of Fourier Transform Raman Spectroscopy in Forensic Science" (**47**).

6.13.3.5 Massonnet and Stoecklein, "Identification of Organic Pigments in Coatings: Applications to Red Automotive Topcoats. Part III: Raman Spectroscopy (NIR FT-Raman)" (**48**).

6.13.3.6 Muehlethaler, et al., "Influence of the Shaking Time on the Forensic Analysis of FTIR and Raman Spectra of Spray Paints" (**49**).

6.13.3.7 Palenik, et al., *Fundamentals of Forensic Pigment Identification by Raman Microspectroscopy: A Practical Identification Guide and Spectral Library for Forensic Science Laboratories* (**50**).

6.13.3.8 Palenik, et al., *Raman Spectroscopy of Automotive and Architectural Paints: In situ Pigment Identification and Evidentiary Significance* (**51**).

6.13.4 *Practical Exercises:*

6.13.4.1 Prepare and analyze several single layer and multiple layered structural and automotive paint samples having a variety of binder types, pigments, extenders and additives.

6.13.4.2 Search several spectra against a spectral library.

6.13.4.3 Perform component classifications for the spectra of several unknown samples.

6.13.5 The methods of instruction for this unit are reading by the trainee and lectures and demonstrations from the trainer.

6.13.6 The method of evaluation for this unit is an evaluation of the practical exercises.

6.14 *Pyrolysis Gas Chromatography/Mass Spectrometry (PGC and PGC/MS):*

6.14.1 This section introduces the trainee to the comparison of a variety of paint binders based on their chemical composition using pyrolysis gas chromatography with flame ionization detection (PGC) or pyrolysis gas chromatography/mass spectrometry (PGC/MS).

6.14.2 Include the following points of instruction:

6.14.2.1 Understanding the theory of PGC or PGC/MS (unless previously authorized to use the instrument).

6.14.2.2 Preparing samples for analysis by PGC or PGC/MS.

6.14.2.3 Performing computer searches of spectral libraries, if available.