



Designation: E 1610 – 02

Standard Guide for Forensic Paint Analysis and Comparison¹

This standard is issued under the fixed designation E 1610; 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 Forensic paint analyses and comparisons are typically distinguished by sample size that precludes the application of many standard industrial paint analysis procedures or protocols. The forensic paint examiner must address concerns such as the issues of a case or investigation, sample size, complexity and condition, environmental effects, and collection methods. These factors require that the forensic paint examiner choose test methods, sample preparation schemes, test sequence, and degree of sample alteration and consumption that are suitable to each specific case.

1.2 This guide is intended as an introduction to standard guides for forensic examination of paints and coatings. It is intended to assist individuals who conduct forensic paint analyses in their evaluation, selection, and application of tests that may be of value to their investigations. This guide describes methods to develop discriminatory information using an efficient and reasonable order of testing. The need for validated methods and quality assurance guidelines is also addressed. This document is not intended as a detailed methods description or rigid scheme for the analysis and comparison of paints, but as a guide to the strengths and limitations of each analytical method. The goal is to provide a consistent approach to forensic paint analysis.

1.3 *Some of the methods discussed in this guide involve the use of dangerous chemicals, temperatures, and radiation sources. This guide does not purport to address the possible safety hazards or precautions associated with its application. 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 and health practices and determine the applicability of regulatory requirements prior to use.*

2. Referenced Documents

2.1 ASTM Standards:

D 16 Terminology Relating to Paint, Varnish, Lacquer, and Related Products²

¹ This guide is under the jurisdiction of ASTM Committee E30 on Forensic Sciences and is the direct responsibility of Subcommittee E30.01 on Criminalistics. Current edition approved Nov. 10, 2002. Published January 2003. Originally published as E 1610 – 94. Last previous edition E 1610 – 95 (2001).

² *Annual Book of ASTM Standards*, Vol 06.01.

D 1535 Method for Specifying Color by Munsell System²
E 308 Test Method for Computing the Colors of Objects by Using the CIE System²
E 1492 Practice for Receiving, Documenting, Storing, and Retrieving Evidence in a Forensic Science Laboratory³

3. Terminology

3.1 *Definitions*—For definitions of terms used in this guide other than those listed in 3.2, see Terminology D 16.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *additive (modifier)*—any substance added in a small quantity to improve properties. Additives may include substances such as dryers, corrosion inhibitors, catalysts, ultraviolet absorbers, plasticizers, etc.

3.2.2 *binder*—a non-volatile portion of a paint which serves to bind or cement the pigment particles together.

3.2.3 *coating*—a generic term for paint, lacquer, enamel, or other liquid or liquifiable material which is converted to a solid, protective and/or decorative film after application.

3.2.4 *discriminate*—to distinguish between two samples based on significant differences; to differentiate.

3.2.5 *discriminating power*—the ability of an analytical procedure to distinguish between two items of different origin.

3.2.6 *known sample*—a coating sample of established origin.

3.2.7 *paint*—commonly known as a pigmented coating (see 3.2.3).

3.2.8 *pigment*—a finely ground, inorganic or organic, insoluble, dispersed particle. Besides color, a pigment may provide many of the essential properties of paint, such as opacity, hardness, durability and corrosion resistance. The term pigment includes extenders.

3.2.9 *questioned sample*—a coating sample whose original source is unknown.

3.2.10 *significant difference*—a difference between two samples that indicates that the two samples do not have a common origin.

4. Quality Assurance Considerations

4.1 A quality assurance program must be used to ensure that analytical testing procedures and reporting of results are monitored by means of proficiency tests and technical audits.

³ *Annual Book of ASTM Standards*, Vol 14.02.

General quality assurance guidelines may be found in “Trace Evidence Quality Assurance Guidelines” (1).⁴

5. Summary of Practice

5.1 Paint films are characterized by a number of physical and chemical features. The physical characteristics may include color, layer sequence and thickness, surface and layer features, contaminants and weathering. Chemical components may include pigments, polymers, additives and solvents. These features can be determined and evaluated by a variety of macroscopical, microscopical, chemical, and instrumental methods. Limited sample size and sample preservation requirements mandate that these methods be selected and applied in a reasonable sequence to maximize the discriminating power of the analytical scheme.

5.2 Searching for differences between questioned and known samples is the basic thrust of forensic paint analysis and comparison. However, differences in appearance, layer sequence, size, shape, thickness, or some other physical or chemical feature can exist even in samples that are known to be from the same source. A forensic paint examiner’s goal is to assess the significance of any observed differences. The absence of significant differences at the conclusion of an analysis suggests that the paint samples could have a common origin. The strength of such an interpretation is a function of the type and/or number of corresponding features.

5.3 An important aspect of forensic paint analysis is the identification of the possible makes, models and years of manufacture of motor vehicles from paint collected at the scene of a crime or accident. The color comparison and chemical analysis of both the undercoat and top coat systems requires a knowledge of paint formulations and processes, collections of paint standards, and databases of color and compositional information.

5.4 The test procedure selected in a paint analysis and comparison begins with thorough sample documentation. Some features of that documentation are described in Practice E 1492. Analysis generally begins with appropriate nondestructive tests. If these initial tests are inconclusive or not exclusionary, the examination may proceed with additional tests, which are selected, based on their potential for use in evaluating and/or discriminating the samples of interest.

6. Significance and Use

6.1 The guide is designed to assist the forensic paint examiner in selecting and organizing an analytical scheme for identifying and comparing paints and coatings. The size and condition of the sample(s) will influence the selected analytical scheme.

7. Collection of Suitable Samples

7.1 The potential for physical matches between known and questioned samples must be considered before selecting the method of paint sample collection. Care should be taken to preserve the potential for a physical match.

7.2 Questioned Samples:

7.2.1 Questioned samples should include all loose or transferred paint materials. Sources of questioned samples can include tools, floors, walls, glass fragments, hair, fingernails, roadways, adjacent structures, transfers or smears on vehicles, or transfers to or from individuals such as damaged fabric with paint inclusions. Whenever possible, items with paint transfers should be appropriately packaged and submitted in their entirety for examination. If sampling is necessary, the procedures listed in “Trace Evidence Recovery Guidelines” (2) may be used. When paint evidence is recognized, every effort should be made to manually remove it before using tape lifts to collect other types of evidence. If paint is collected with tape lifts, one should be aware of the possible difficulty encountered when attempting to manipulate paint samples bearing adhesive residues. In addition, components of the adhesive could contaminate the paint sample and change its apparent chemistry.

7.2.2 Smear transfers can exhibit mingling of components from several layers or films that could preclude application of some of the analytical methods discussed in this guide. Due to the difficulties associated with collecting smeared or abraded samples, the entire object bearing the questioned paint should be submitted to the laboratory whenever possible.

7.2.3 When contact between two coated surfaces is indicated, the possibility of cross-transfers must be considered. Therefore, if available, samples from both surfaces should be collected.

7.3 Known Samples:

7.3.1 When feasible, known paint samples must be collected from areas as close as possible to, but not within, the point(s) of damage or transfer. These damaged areas are usually not suitable sources of known samples. The collected known samples should contain all layers of the undamaged paint film. Substantial variations in thickness and layer sequences over short distances can exist across a painted surface. This is particularly true in architectural paint and for automotive films where the curves, corners, and edges are often impact points and may have been subjected to previous damage, sanding or over-painting. If necessary, several known paint samples should be taken to properly represent all damaged areas. Known paint samples collected from different areas should be packaged separately and labeled appropriately.

7.3.2 When possible, the surface underlying the suspected transfer area should be included for analysis. Adjacent sections removed from a wall, ceiling, door, window, implement handle, and automobile door, fender, and hood are examples of items that can be valuable for assessing questioned and known sample differences and evaluating the possible cross transfer of trace materials.

7.3.3 Paint flakes can be removed from the parent surface by a number of methods. These include but are not limited to the following: lifting or prying loosely attached flakes, cutting samples of the entire paint layer structure using a clean knife or blade, or dislodging by gently impacting the opposite side of the painted surface. When cutting, it is important that the blade be inserted down to the parent surface. It should be noted that no one method of sampling should be relied upon exclusively.

⁴ The boldface numbers in parentheses refer to the list of references at the end of this standard.

8. Procedure

8.1 Discussions of forensic paint analysis are provided in dated but detailed form by Crown (3), and more recently by Nielsen (4), Thornton (5), Maehly and Strömberg (6) and Stoecklein (7).

8.2 A reasonable scheme for forensic paint examinations is outlined in Figs. 1-4. Potentially useful techniques for the discrimination of paint binders, pigments, and additives are listed. The major steps in Fig. 1 are numbered to correspond to the discussions presented in this guide (for example 8.8, Solvent Tests). For any given comparison, not all the techniques listed in the same area in Fig. 1 are necessarily required. Sample size, condition and layer structure complexity should be considered when determining which techniques to use. The forensic coatings examiner should always use the more specific and least destructive tests prior to those that require more sample preparation or consumption. A review of the general technique descriptions, listed in 8.8-8.15, will provide guidance for the selection of appropriate methods.

8.3 Fig. 1 does not imply that other examinations should be excluded or that the order of the procedures in the chart is

irrevocable. Samples that are neither constrained by amount nor condition should be subjected to analyses that will determine the color and texture of the paint as well as the number, order, colors and textures of the layers in a multi-layered sample. In most cases, instrumental techniques should be employed to analyze and compare both the pigment and binder portions of the sample. A combination of techniques, which provide discrimination between as many types of paints and coatings as possible, should be used. These techniques should also be selected to provide classification and/or component identification information to be used in significance assessments. For samples that are limited in layer structure complexity, techniques for the comparison of both the binder and pigment portion of the coating must be used. The choice of techniques may change depending upon sample characteristics. For instance, pyrolysis-gas chromatography (PGC) may be utilized for identifying and comparing the binder portion of samples that exhibit a low binder concentration. Likewise, scanning electron microscopy-energy dispersive X-ray analysis (SEM-EDS), X-ray fluorescence (XRF) and X-ray diffraction

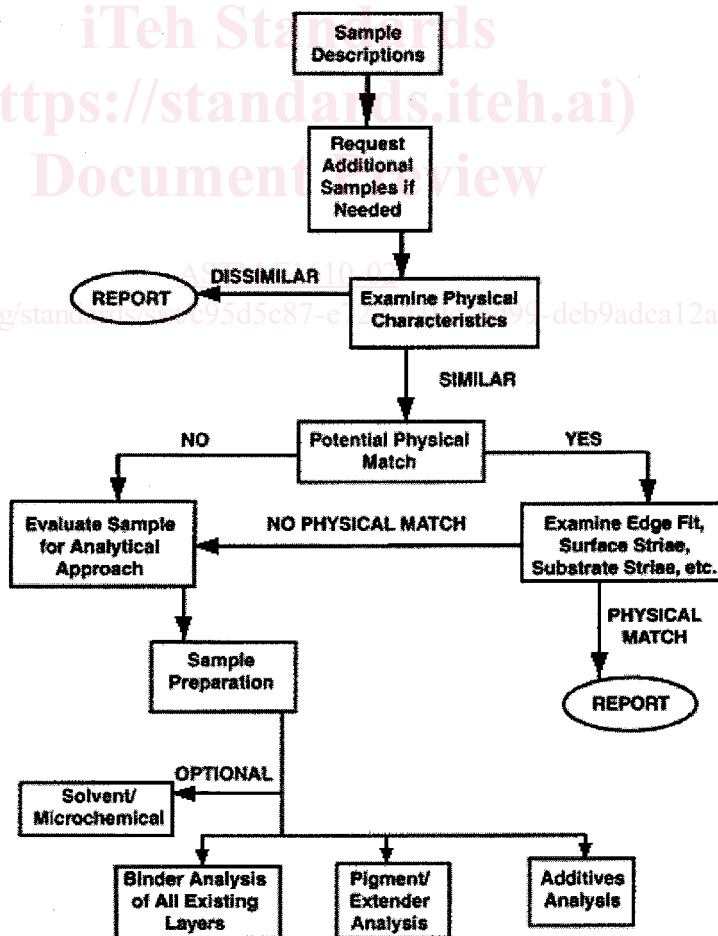


FIG. 1 Scheme for Forensic Paint Examinations

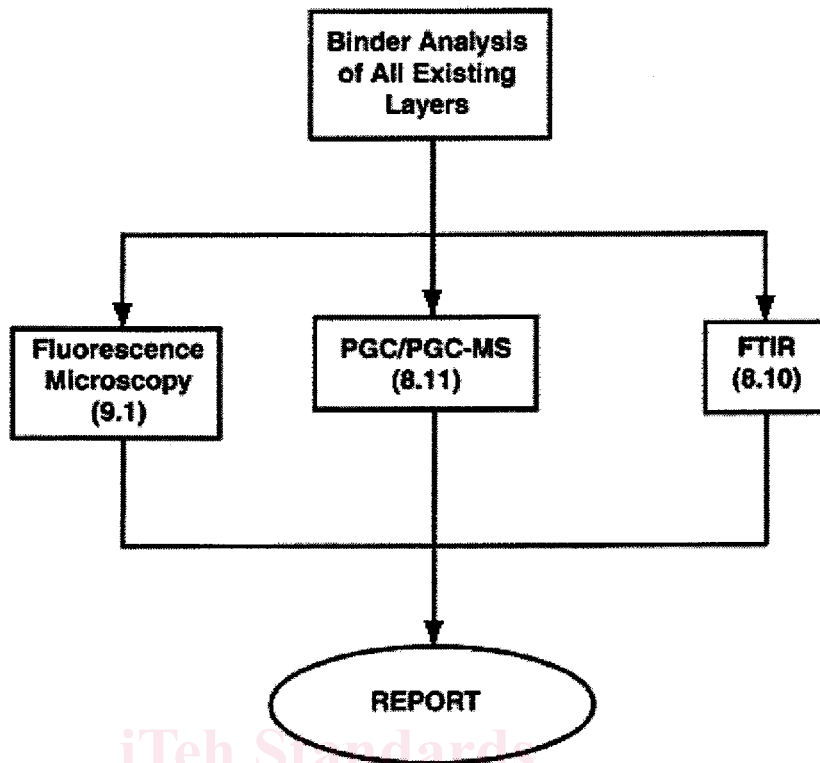


FIG. 2 Scheme for Forensic Paint Examination

(XRD) may be used for identifying and comparing the pigment portion of samples that exhibit a low pigment concentration.

8.4 The flow-chart in Fig. 5 is a guide to the determination of the possible origins of a motor vehicle paint in an investigative case. It is usually possible to differentiate motor vehicle repaint from the original equipment manufacturer (OEM) paint by microscopical examination. If no OEM paint is present, then only the vehicle color can be reported. For OEM paint, the color of the topcoat layers and of the undercoat layers will each be useful in identifying manufacturer, model and year. Often the two systems provide complementary information. In most cases a range of possible makes/models/years will be generated by the search. Further specific information can often be developed through chemical analysis of the individual layers. Any of the techniques shown in Fig. 1 can be used, depending on the databases available. Reference collections and databases include books of color chips produced by automotive refinish paint manufacturers for use by body shops and automotive repair facilities, manufacturer topcoat and undercoat color and chemical standards, “street” samples collected from damaged motor vehicles, OEM information on paint formulations and collections of infrared spectra or pyrograms of known paints. Examples of these include the Royal Canadian Mounted Police/Technical Working Group on Materials Analysis (RCMP/TWGMAT) database, the National Automotive Paint File which is maintained by the Federal Bureau of Investigation (FBI), the Collaborative Testing Services reference collection of automotive paints and the Georgia Bureau of Investigation Paint Library of infrared spectra.

8.5 Sample Description:

8.5.1 The first step in forensic paint analysis is the visual and macroscopical evaluation, description, and documentation of the original condition of the sample(s). Occasionally, this can be the final step in an analysis if exclusionary features or conditions in the sample(s) are identified during the initial evaluation.

8.5.2 The initial evaluation should begin with a critical review of the samples’ chain of custody, package sealing, identification markings, and any potential cross-contamination between samples. If the items are found to be suitable for further evaluation, a detailed accounting and description of the paint fragments and any co-mingled material should be documented. This involves describing the general condition, weathering characteristics, size, shape, exterior colors, and major layers present in each sample. This description can be accomplished by examining each item using a stereomicroscope.

8.5.3 Written descriptions, sketches, photography or other imaging methods must be used to document each sample’s characteristics. The goal is to produce documentation that will be meaningful to a reviewer in the absence of the recording examiner. The resulting notes must be sufficient to document the conclusions reached in the examiner’s report. Although documentation is discussed at this point in the guide, it is an essential part of all steps in an analysis.

8.6 Physical Match:

8.6.1 The most conclusive type of examination that can be performed on paint samples is the physical matching of samples. This may involve the comparison of edges and surface striae between samples or the comparison of surface striae on the underside of a questioned paint fragment to those

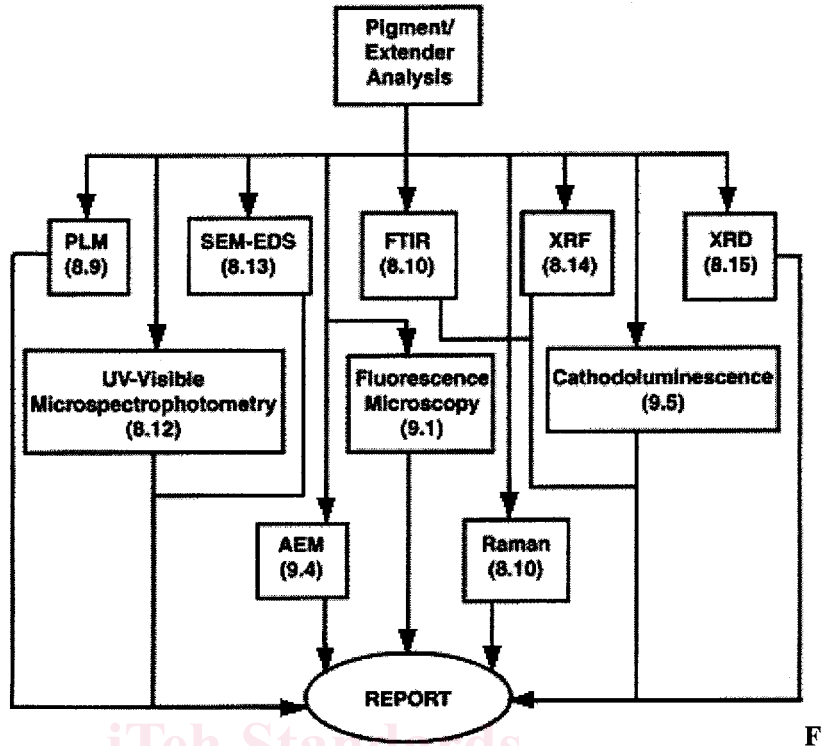


FIG. 3 Scheme for Forensic Paint Examinations

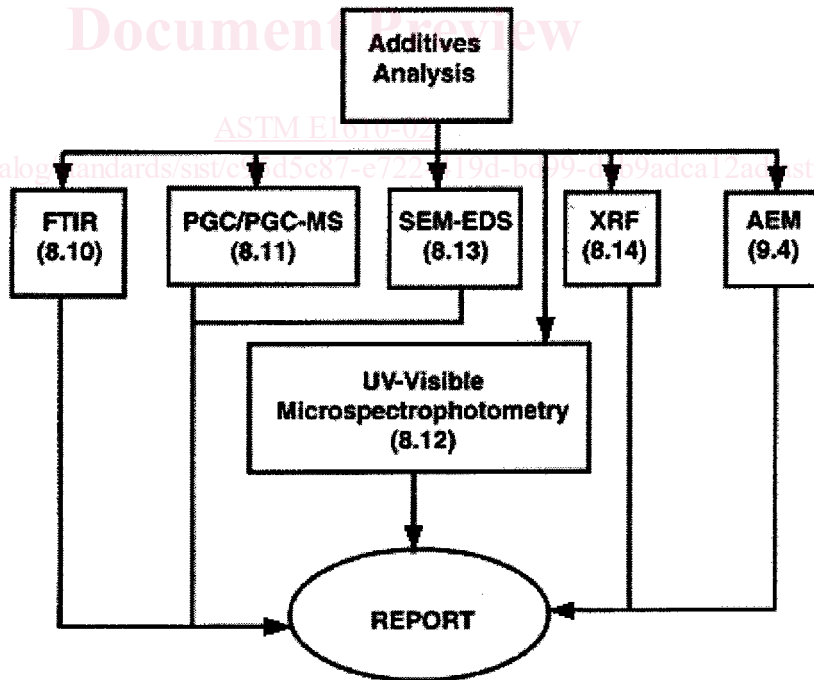


FIG. 4 Scheme for Forensic Paint Examinations

of a parent surface. The edges and/or striae in question must possess unique characteristics.

8.6.2 Physical matches must be documented with descriptive notes. Photography, phototransparency overlays or other

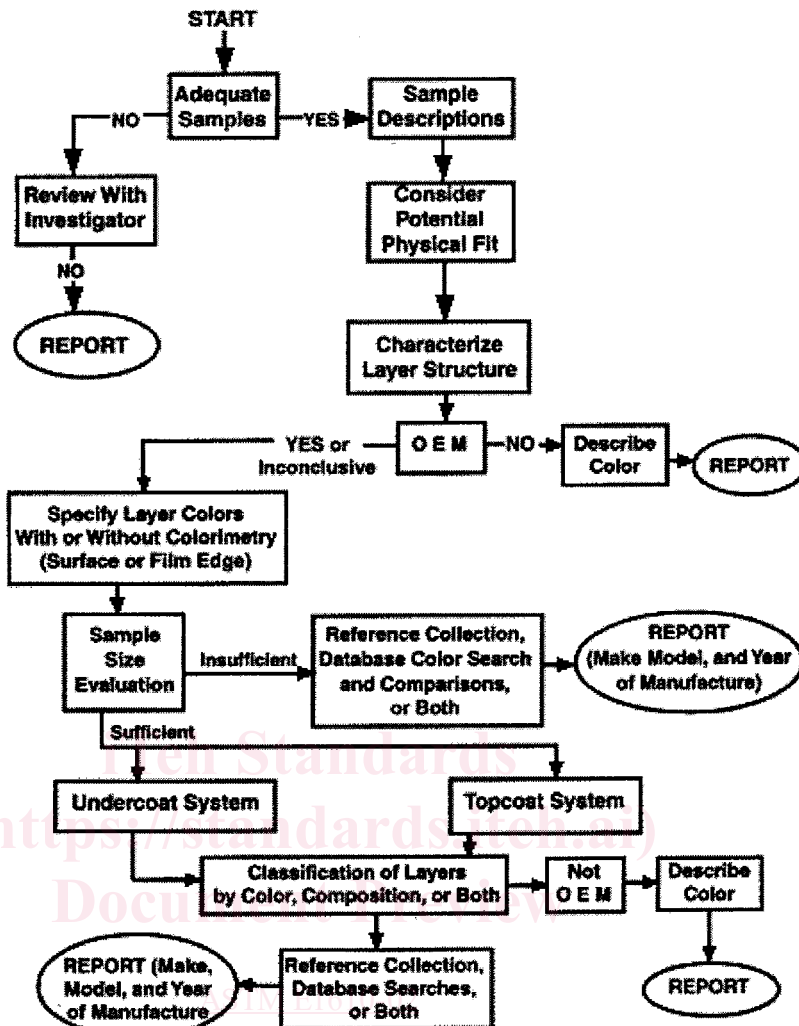


FIG. 5 Guide to the Determination of the Possible Origins of a Motor Vehicle Paint In An Investigative Case

appropriate imaging techniques may be a useful adjunct. When imaging methods are used to document a physical match, the examiner must ensure that the method employed is dimensionally accurate and has associated measuring scales. Images must be well preserved and retained as part of the documentation.

8.7 Sample Preparation and Layer Analysis:

8.7.1 The layers in a paint film are identified by viewing of sample edges at magnifications ranging between $5\times$ and $100\times$. The more obvious layers are generally visible without sample preparation. Definitive paint layer identification usually requires sample preparation techniques such as manual or microtome sectioning and/or edge mounting and polishing. A combination of techniques may be required to fully characterize the layer structure. The extent of sample manipulation and preparation will depend on the amount of paint available and its characteristics.

8.7.2 Paint layer structure can be observed by using a scalpel blade to make an oblique cut through a sample. The larger surface area created by this angled cut may enhance layer visualization and assist in the detection of layer inhomogeneities.

The preparation of thin-sections and the separation of paint layers can be accomplished with a scalpel blade. Preliminary solvent tests can be conducted on the manually prepared sections and layer fractions.

8.7.3 Subtle differences in color, pigment appearance, surface details, inclusions, metallic and pearlescent flake size and distribution, and layer defects, may require microscopical comparisons of the edge, oblique cut and surface views of known and questioned paint samples. These comparisons must be carried out with both samples positioned side by side and in the same field of view.

8.7.4 Cross-sections (embedded or thin-section preparations) may provide additional information as to the layer sequence, layer thickness, color, pigment distribution, pigment size, and composition of the individual layers that may not be possible to obtain with gross examination. Embedded preparations can be prepared by polishing and/or microtomy. Thin-sections can be prepared using a variety of microtomy techniques. Examination and analysis of the cross-sections can be conducted using a variety of analytical techniques that may