Trace Evidence Quality Assurance Guidelines

Scientific Working Group on Materials Analysis (SWGMAT)
January 1999 Revision

1.0. Scope

The goal of a laboratory's trace evidence analysis program is to provide quality trace evidence assessment, identification, comparison, and reconstruction associated with forensic investigations. These guidelines provide a framework of standards for quality in the processing of trace evidence collection, handling, analysis, reporting, and testimony.

1.1. A quality assurance program must be established and maintained. The personnel responsible for the program must have it clearly stated in their position descriptions and should have direct authoritative access to the highest level of management concerning laboratory policy. Standard operating procedures must document who may take what action, whether approval is required, and from whom approvals are needed.

1.2. The quality assurance program must ensure that all procedures, examinations, and reports associated with trace evidence are within the established guidelines.

2.0. Significance and Use

This document pertains to the personnel performing trace evidence examinations in forensic laboratories.

3.0. Terminology

Administrative Review: Review of a report for compliance with laboratory policy and editorial correctness.

Audit: An inspection to evaluate laboratory function and compliance with established criteria.

Calibration: The process of assigning a known value, within specified limits, to an instrument's scale reading.

Examiner: Personnel who receive and examine evidence, interpret results, write reports, and testify to casework findings.

Proficiency Test: Personnel and laboratory evaluation through the examination and interpretation of a prepared sample.

Quality Assurance: Planned actions to provide confidence that a service will meet certain requirements.

Quality Control: Daily operational procedures designed to ensure quality results.

Reference Sample: A material of known physical characteristics authenticated by a certified procedure accompanied by or traceable to documentation.

Structured Courses: Courses providing continuing education credit or courses documenting specific goals and that have detailed agendas and written examinations testing student comprehension.

Support Analysts: Personnel highly trained and knowledgeable in the operations of specialized laboratory instrumentation. These personnel are responsible for instrument operation and the analysis of evidence utilizing these instrument. According to state and/or laboratory policy, the support personnel may be required to provide a written report and testify to the interpretations in a court of law.

Systematic Error: Any discrepancy due to improper instrument function.

Technical Peer: An examiner technically current and competent in the same trace discipline.

Technical Review: Report review by a technical peer for content and supporting data.

Technicians and Laboratory Aides: Personnel who provide laboratory support and assist with the basic functions of the section. These functions should be specified by laboratory policy and may include preparing reagents, cleaning glassware, ordering supplies, and preparing samples for examination.

Trace Evidence: Referring to the forensic discipline involving the examination of fibers, hairs, glass, and paint.

Validation: The acquisition of information needed to assess the reliability of a procedure and to determine the conditions under which results can be obtained.

4.0. Personnel

The job descriptions for all personnel should include responsibilities, duties, and required skills.

4.1. Designated Personnel and Responsibilities

Personnel may be responsible for more than one of the following duties.

4.2.1. *Case Coordinator (However Named):* Designated personnel with extensive knowledge of the laboratory's capabilities and of forensic science to prioritize cases and direct case flow.

4.2.2. *Quality Assurance Coordinator (However Named):* Designated personnel who monitor compliance with the quality assurance program.

4.2.3. *Technician and Laboratory Aide (However Named):* Designated personnel who perform basic laboratory duties but do not examine evidence.

4.2.4. *Support Analyst (However Named):* Designated personnel responsible for the operation and analysis of evidentiary samples on specialized laboratory instrumentation.

4.2.5. *Examiner (However Named):* Designated personnel who receive and examine evidence, interpret results, write reports, and testify to casework findings.

4.2.6. *Technical Manager (However Named):* Designated personnel who have the overall responsibility and authority for the technical operations of the trace evidence section. Technical operations include, but are not limited to, developing protocols and analytical methodologies and evaluating report writing and conclusions.

4.2.7. *Technical Consultant (However Named):* Designated personnel who have the responsibility and authority for the technical operations of specific trace discipline(s) when the technical manager is not qualified in specific discipline(s). Personnel report directly to the technical manager to ensure the operations are maintained.

In the event that no personnel in the laboratory system have the qualifications to be a technical consultant, a qualified consultant must be retained from outside the laboratory to perform technical consultant duties until in-house personnel obtain the necessary qualifications. The consultant will have the same technical responsibility and authority as an in-house technical consultant.

4.3. Qualifications and Education
Technicians and laboratory aides will

- have the education, skills, and ability commensurate with their responsibilities and
- have on-the-job training specific to their position.

Examiners and support analysts will

- exhibit knowledge of the theories, procedures, and analytical techniques necessary to produce reliable results and conclusions;
- have a minimum of a bachelor of arts or a bachelor of science degree in a natural or applied science; and
- have successfully completed the college course work (undergraduate or graduate) and structured course work as listed under one of the specific addenda.

These requirements must be completed within two years of the issuance of this document.

Technical leaders and technical consultants will

- exhibit knowledge of the theories, procedures, and analytical techniques necessary to evaluate results and conclusions; and
- have a master of science or doctoral degree applicable to the profession and at least five years of experience as an examiner in the forensic analysis of at least one trace evidence discipline;

or

- have a bachelor of science degree in a natural or applied science and five years of experience as an examiner in the forensic analysis of at least one trace evidence discipline, successful completion of an accepted forensic certification program or documented laboratory testing program, and successful completion of advanced course work in microscopy and instrumentation;

- have successfully completed college course work (undergraduate or graduate) and structured course work as listed under one of the specific addenda; and

- demonstrate competency by completing a year's requirement in 2.5.2 prior to or concurrent with the appointment to technical manager.

The laboratory must establish and document qualifying procedures or a training program for all new technician and laboratory aide, support analyst, and examiner trainees. Trace evidence training programs must enable the trainees to obtain the specialized knowledge and skills required to demonstrate ability in each discipline in which they will be qualified.

Technician and laboratory aide trainees must follow an outline showing an approximate time line for completion of training, including completion of a training manual covering the principles and methodology of tasks for which they will be responsible. A reference list may be used to supply this information.

Examiner and support analyst trainees must follow an outline showing an approximate time line for the completion of training, including the completion of a training manual covering principles, uses, and applications of the instruments and the methods and procedures applied during task performance. A reference list may be used to supply this information.

Examiner and support analyst trainees must observe an experienced examiner handling casework prior to working cases under the direct supervision of an experienced examiner. Prior to undertaking independent casework, examiner and support analyst trainees must demonstrate competency through successful completion of the following:

- Proficiency test(s),

- Written and/or oral exam(s), and

- Command of oral skills in presenting the subject (moot court).

The laboratory must establish a documented means of recognition for the successful completion of training such as a certificate, letter, or memorandum.

4.4. Maintaining Qualifications
In order to maintain qualifications, examiners and support analysts must annually

- successfully complete proficiency test(s) in trace evidence;

- actively participate in casework examinations;

- undergo reviews of testimony by a technical peer, technical manager, or technical consultant when testimony is required; and

- participate in at least one of the following:

    - attend professional forensic association meetings or workshops;

    - attend technical training courses;

    - attend college-level courses;

- conduct research or method development;
- publish a technical paper in a peer-reviewed, scientific journal; and
- read current professional literature including journals and books.

In order to maintain qualifications, a technical manager or technical consultant must annually

- successfully complete proficiency test(s) in trace evidence and
- participate in at least one of the following:
  - present a technical paper at a professional meeting;
  - instruct workshops or technical training courses;
  - conduct research or method development;
  - actively participate in an organization dealing with the technical advancement of forensic trace analysis;
  - publish a technical paper in a peer-reviewed, scientific journal; and
  - read current professional literature, including journals and books, and discuss and critique the relevancy of selected topics.

5.0. Documentation

The forensic laboratory must maintain documentation on significant aspects of trace evidence analysis procedures, including any related documents or laboratory records pertinent to the analysis or interpretation of results, to create a documented audit trail. Documentation should also exist for the following areas.

5.1. Test Methods and Procedures
The documents must describe in detail the protocols currently used for the analytical testing of trace evidence. The protocols must identify the reference standards and required controls. Revisions must be clearly documented and appropriately authorized.

5.2. Authenticated Reference Samples
List the source and include the data document or the manufacturers' letter of authenticity.

5.3. Reagents Documentation (Date of Receipt, Opening, and Preparation)

5.4. Evidence-Handling Protocols

5.5. Equipment Calibration and Maintenance Records

5.6. Equipment Inventory (Manufacturer, Model, Serial Number, and Acquisition Date)

5.7. Proficiency Testing Data

5.8. Personnel Training and Qualification Records

5.9. Quality Assurance and Audit Records

5.10. Quality Assurance Manual

5.11. Safety Manuals

5.12. Material Safety Data Sheets

6.0. Equipment and Materials

Only suitable and properly operating equipment should be employed. Monitoring of equipment parameters should be conducted and documented as specified in Sections 5.5. and 5.6. The manufacturer's operation manual for each instrument should be available at the work place.

Materials and chemicals must be of suitable quality and demonstrated to be compatible with the methods employed. Documentation must be maintained for chemicals and must include the date received and the date of opening or preparation. There must be written formulae for all chemical reagents produced in the laboratory. Labels for reagents prepared within the laboratory must include

- the identity, concentration (when appropriate), and date of preparation;
- the identity of the personnel preparing the chemicals; and
- the storage requirements, if applicable, according to laboratory policies and/or appropriate regulations.

Commercial and laboratory-prepared reagents must be tested against a reference sample prior to use in casework. The results of the test must be documented. Supplies must be inspected for cleanliness appropriate for the analysis performed.

7.0. Analytical Procedures

The analysis of unknown trace evidence can be accomplished by a variety of methods. Nondestructive tests should be performed first. Limited sample size, the possibility of future analyses, and other limitations should be considered before destructive tests are performed. Appropriate reference samples or collections must be authenticated. Refer to established published procedures.

The laboratory's quality control guidelines should contain specific protocols to assess critical parameters in normal operations. Instruments must be routinely monitored to ensure that performance is maintained and documented. Instrumentation used in the analysis of trace evidence must be tested with reference standards, when appropriate, to ensure that the instruments are performing adequately.

Documentation must be maintained to create an audit trail that can be reviewed. Documentation must contain sufficient information to allow a technical peer to evaluate case notes and interpret the data.

Documentation should include data obtained through the analytical process. It should also include information regarding the packaging of the evidence upon receipt and the condition of the evidence. All documentation of procedures, standards, controls, observations, results of the tests, charts, graphics, photographs, printouts (hard copy and disk), spectra, and communications generated during an examination must be preserved according to written laboratory policy.

Reports should contain the following:

- Name and address of the laboratory;
- Case identifier;
- Name, address, and identifier of the contributor;
- Date of receipt;
- Date of report;
- Descriptive list of submitted evidence;
- Identification of the methodology;
- Identity and signature of examiner; and
- Results and conclusions.

A case review should be conducted by a minimum of two personnel. The review should consist of a technical review and an administrative review. A technical review should be conducted on each report and the notes and data supporting the report must be reviewed independently by a technical peer. Once a report has been reviewed, initials or other appropriate markings must be maintained in the case file by the personnel conducting the review. An administrative review should be conducted on each report to ensure adherence to laboratory policy and editorial correctness.

Laboratory administration will determine the course of action if an examiner and the reviewer fail to concur.

8.0. Proficiency Testing

Proficiency testing pertains to examiners, support analysts, technical managers, and technical consultants engaged in the field of trace evidence. At least one proficiency test must be completed annually by each of the personnel.

Test samples must be of sufficient quality so that a conclusion can be drawn from the results of the analysis. All test samples must be handled and stored appropriately to maintain their integrity and condition.

The following proficiency test data and information must be collected and submitted to the quality assurance coordinator or other designated personnel for evaluation:

- Proficiency test identifier;
- Identity of examiner;

- Dates of analysis and completion;
- Copies of all data sheets and notes;
- Copies of all charts, graphs, and printouts; and
- Results and conclusions.

The quality assurance coordinator or other designated personnel will review all test documentation and compare the results with the information received from the manufacturer of the test. The quality assurance coordinator will provide a written summary report for each proficiency test to the participating examiner or other appropriate personnel as established by the laboratory policy. This review should be conducted in a timely manner.

All original notes, records, and other data pertaining to the open proficiency test results must be retained according to laboratory policy.

Prior to a proficiency test, all participating laboratory personnel should be provided with the specific policies, procedures, and criteria for any corrective action that may be taken as a result of a discrepancy in a proficiency test.

It is the responsibility of the quality assurance coordinator or designated personnel to ensure that discrepancies are acknowledged, the reasons for any discrepancies are determined, and any subsequent corrective action is documented.

Any discrepancy in a proficiency test determined to be administrative (clerical, sample confusion, improper storage, or documentation) will be corrected according to established laboratory policy.

Any discrepancy in a proficiency test determined to be the result of a systematic error may require a review of all relevant casework since the trace evidence section's last successfully completed proficiency test using that equipment. Once the cause of the discrepancy has been identified and corrective action has been taken, examiners in the relevant area should be made aware of the appropriate corrective action.

Any difference in a proficiency test result proven to be the consequence of an analytical or interpretative discrepancy may prohibit the personnel who produced the discrepant result from further examination of case evidence until the cause of the discrepancy is identified and corrected. The quality assurance coordinator or designated personnel will determine the need to audit prior cases according to established laboratory policy.

Before resuming analysis or interpretation of casework, one additional proficiency test should be successfully completed by the personnel responsible for the discrepancy.

The results of all proficiency tests should be maintained by the laboratory according to established laboratory policy.

9.0. Validation

The laboratory will use validated techniques and procedures. Techniques and procedures (e.g., ASTM 1492-92) currently accepted by the scientific community should be considered valid.

New techniques developed for the characterization, identification, and comparison of trace evidence should be based on accepted scientific principles. Validation studies should be performed as soon as practicable to establish the technique's reliability.

It is important that the results of validation studies be shared as soon as possible with the scientific community through presentations at scientific and professional meetings and through timely publication in peer-reviewed, scientific journals.

10.0. Laboratory Audits

Audits should be conducted at least once a year by the technical manager in conjunction with the personnel responsible for the quality assurance program.

Records of each audit should be maintained and should include the date of the audit, name of the person conducting the audit, findings, and corrective actions, if necessary.

The laboratory must establish an audit schedule. Case files to be reviewed should be chosen randomly.

11.0. Safety

The trace evidence laboratory should operate in accordance with the regulations of the pertinent government, environmental, health, biohazard and safety authorities, and laboratory policy.

General laboratory safety manual(s) should be readily available to all laboratory personnel.

A Material Safety Data Sheet (MSDS) file should be maintained for chemicals used in the laboratory. These data sheets should be updated regularly and be readily available to all laboratory personnel.

All chemicals, biohazards, and supplies must be stored and disposed of according to applicable government regulations and laboratory policy.

12.0. Bibliography

American Society of Crime Laboratory Directors-Laboratory Accreditation Board, *ASCLD-LAB Accreditation Manual*, 1994.

Garfield, F. M. *Quality Assurance Principles for Analytical Laboratories*, Association of Official Analytical Chemists, Library of Congress, 1991.

International Standards Organization/International Electrotechnical Commission, *ISO/IEC Guide 25-1990*, American National Standards Institute, New York, 1990.

OSHA. *U.S. Department of Labor Occupational Safety and Health Administration*. U.S. Government Printing Office, 1984.

Quality Assurance, *Laboratory Management Practice Manual*, American Council of Independent Laboratories, 1986.

TWGDAM. Guidelines for a Quality Assurance Program for DNA Analysis. Technical Working Group on DNA Analysis Methods, *Crime Laboratory Digest* (1995) 22:21-43.

Fiber Addenda
FA2.3.2.3 and FA2.3.3.3

Successful completion of the following undergraduate or graduate courses:

1. One year (or equivalent) general chemistry with laboratory work;

2. One year (or equivalent) organic chemistry with laboratory work; and

3. General biology with laboratory work.

If the following courses are not available at the graduate or undergraduate level, then structured course work is required:

4. Analytical/Instrumental Analysis;

5. Basic Microscopy and Polarized Light Microscopy; and

6. Fiber Microscopy.

Fiber Addendum
FA2.4.1.2.a

The training period will be a minimum of 12 months, full time, for the inexperienced trainee examiner with no prior forensic experience. (The allotted time is to include all those specifications under Sections 2.4.1.2, 2.4.1.3 and 2.4.1.4. These sections refer to casework observation, supervised casework, proficiency test[s], examinations, and moot courts.)

Suggested topics for the time line follow:

Introduction to Fibers

A. Fiber History, Usage, and Manufacturing

B. Fiber Classification

C. Fiber and Textile Technology and Terminology

D. Chemistry and Manufacturing Processes (Polymers and Dyes)

E. Identification Versus Comparison

F. Overview of Forensic Fiber Examinations

G. Transfer and Persistence of Fibers

H. Associated Examinations

Collection and Preservation

A. Fiber Search and Recovery

B. Sample Handling

C. Contamination

D. Packaging

E. Documentation

Sample Preparation Methods

Identification of Vegetable Fibers

A. Botanical Classification

B. Morphology and Anatomy

C. Methods of Identification

Identification of Animal Fibers

A. Zoological Classification

B. Morphology and Anatomy

C. Methods of Identification

Identification of Inorganic Fibers

A. Classification

B. Methods of Identification

Identification of Manufactured Fibers

A. Generic Classification

B. Microscopic Characterization

1. Stereomicroscopy

2. Polarized Light Microscopy (PLM)

3. Infrared Microspectroscopy

C. Solubility

D. Instrumental Methods

Fiber Comparisons

A. Microscopic Examinations

1. Comparison Microscopy

2. Fluorescence Microscopy

B. Color Analysis

1. Dye Classification

2. Thin-Layer Chromatography

3. Microspectrophotometry

C. Instrumental Methods

Instrumental Methods

A. Fourier Transform Infrared Spectroscopy (FT-IR) or FT-IR with Microscope

B. Microspectrophotometry (UV-VIS/VIS)

C. Thermal Microscopy

D. Pyrolysis Gas Chromatography

E. Scanning Electron Microscopy/Energy Dispersive Spectroscopy (SEM/EDS)

F. Other Techniques

Fabrics

A. Construction and Composition

B. Physical Match

C. Examination of Damage

D. Impressions

Ropes and Cordage

A. Construction and Composition

B. Physical Match

C. Knots

Interpretation and Presentation

A. Factors Affecting Evidence Interpretation

B. Significance of Fiber Evidence

C. Report Writing

D. Testimony

Training Evaluation

A. Written and Oral Examinations

B. Competency Testing

C. Supervised Casework

D. Moot Court

Glass Addendum
GA2.3.3.3

Successful completion of the following undergraduate or graduate courses:

1. One year (or equivalent) general and/or introductory chemistry with laboratory work;

2. Instrumental quantitative analysis with laboratory work
and statistical interpretation of data; and

3. Physics with laboratory work and topics mechanics
and optics.

If the following course is not available at the graduate or undergraduate level, then completion through structured course work is required:

4. Light Microscopy: Theory and Practice with Basic PLM.

Glass Addendum
GA2.4.1.2a

The training period will be a minimum of 12 months, full time, for the inexperienced trainee examiner. The allotted time includes the specifications under sections 2.4.1.2, 2.4.1.3, and 2.4.1.4. These sections refer to casework observation, supervised casework, proficiency test(s), examinations, and moot court.

Suggested inclusion topics for the time line follow:

Introduction to Glass Technology

A. Definition of Glass

B. Physical Structure and Properties

C. Types of Glass and End Uses

D. Chemical Composition of Glass

E. History of Glass Manufacture

F. Production Methods and Processes for Glass Types

G. Strengthening of Glass

H. Transfer and Persistence and Survey Studies

Collection and Packaging

A. Glass Collection and Packaging Techniques

B. Contamination Implications

Macroscopic Examinations

A. Fracture Examinations

B. Color

C. Size and Shape

D. Surface Finishes and Texture

E. Thickness

F. UV Fluorescence

Examination of Physical Properties

A. Density

B. Thickness

C. Color

D. Other

Microscopic Examinations

A. Microscopic Recognition of Glass

B. Classification by Optical Properties

C. Microscopic Fracture Characterization

D. Interferometry

E. Float Surfaces

Determination of Refractive Index

A. Reannealing

B. Dispersion

Elemental Analysis

A. Scanning Electron Microscopy (SEM) with
Energy Dispersive X-ray Spectrometry (EDS) and
Wavelength Dispersive X-Ray Spectrometry (WDS)

B. X-Ray Fluorescence Spectrometry (XRF)

C. Emission Spectroscopy (ES)

D. Atomic Absorption Spectrometry (AA)-Flame
and Graphite Furnace

E. Inductively Coupled Plasma-Atomic Emission
Spectrometry (ICP/AES)

F. Inductively Coupled Plasma-Mass Spectrometry (ICP-MS)

G. Neutron Activation Analysis (NAA)

Interpretation of Results

A. Accuracy and Precision of Analytical Measurements

B. Discrimination Criteria

C. Classification

D. Databases

E. Report Writing and Testimony

Hair Addenda
HA2.3.2.3 and HA2.3.3.3

If the following is not available at the graduate or undergraduate level, completion through structured course work is required:

Basic Microscopy and Polarized Light Microscopy

Hair Addendum
HA2.4.1.2a

The training period will be a minimum of 12 months, full time, for the inexperienced trainee examiner. The allotted time includes the specifications under sections 2.4.1.2, 2.4.1.3, and 2.4.1.4. These sections refer to casework observation, supervised casework, proficiency test(s), examinations, and moot court.

Suggested inclusion topics for the time line follow:

I. Introductory Reading Assignments on Fundamental Knowledge

A. Hair Structure and Ultrastructure

B. Hair Chemistry and Biochemistry

C. Hair Anomalies and Diseases

D. Hair Growth Phases

E. History of Hair Examinations

F. Implications of Hair Structure, Chemistry, and Growth
for Forensic Hair Comparison

II. Evidence Recognition and Handling Techniques

A. Collection of Known/Exemplar Hairs

B. Evaluation of and Practice With Recognition and Collection Techniques for Evidence Hairs

C. Contamination Issues

D. Preservation

E. Recognition of Environmental Effects on Hair

III. Macroscopic and Low-Power Microscopic Evaluation of Hair

A. Color

B. Length

C. Shape

D. Racial and Somatic Origin

E. Texture and Conformation

F. Gross Surface Contaminants

G. Observation of Variation Along Length of Hair

H. Human Versus Animal Hair Features

IV. Microscopic Examination of Hair

A. Preparation Technique

1. Scale Casts

2. Considerations With Mountants

3. Considerations With Slides and Cover Slips

4. Mounting Techniques

5. Considerations With Cross-Sectioning

6. Miscellaneous Techniques

B. Microscopic Techniques

1. Basic Light Microscopy

2. Polarized Light Microscopy

3. Comparison Microscopy

4. Miscellaneous Microscopic Methods

C. Microscopic Characteristics

1. Human and Animal

2. Somatic and Racial

3. Comparison Characteristics

D. Consideration/Evaluation of Acquired Characteristics

1. Dyes and Cosmetics

2. Environmental Contaminants

3. Environmental Damage

4. Insect and Other Types of Damage

V. Evaluation of Hair Features Used in Comparison

A. Practice With Known Hairs

B. Practice Comparing Questioned Hairs to Knowns

C. Practical Testing

D. Competency Testing (Written, Practical, and Oral)

VI. Evaluation of Hairs for DNA Profiling

VII. Documentation

A. Notes

B. Report Writing Including Criteria for Exclusion
and Inclusion

VIII. Evaluation and Interpretation

IX. Testimony

Paint Addenda
PA2.3.2.3 and PA2.3.3.3

Successful completion of the following undergraduate or graduate courses:

1. One year (or equivalent) general chemistry
with laboratory work,

2. One year (or equivalent) organic chemistry
with laboratory work, and

3. Analytical/instrumental analysis.

If the following is not available at the graduate or undergraduate level, completion through structured course work is required.

4. Light Microscopy With Basic Polarized Light
Microscopy (PLM)

Paint Addendum
PA2.4.1.2a

The training period will be a minimum of one year, full time, for the inexperienced trainee examiner. The allotted time includes the specifications under Sections 2.4.1.2, 2.4.1.3, and, 2.4.1.4. These sections refer to casework observation, supervised casework, proficiency test(s), examinations, and moot court.

Suggested inclusion topics for the time line follow:

I. General Background

A. Encountering Paint Evidence

B. History of Paint, General and Forensic Terminology

C. Use and Composition of Paint

D. Overview of Forensic Paint Examinations

II. Search and Collection Techniques (Reference Recovery Guide)

A. Clothing

B. Motor Vehicles

C. Other Objects

III. Microscopic Examination and Characterization

A. Fracture Characteristics and Comparisons

B. Surface Defects and Contaminants

C. Sample Preparation Techniques

D. Microscopic Recognition and End-Use Classification

E. Microscopic Comparisons

IV. Solvent and Microchemical Examinations

A. Binder Classification

B. Microchemical Comparisons

V. Binder Examinations

A. Binder Classification

B. Infrared Spectroscopy

C. Pyrolysis Gas Chromatography

D. Pyrolysis Gas Chromatography/Mass Spectrometry

E. Pyrolysis Mass Spectrometry

F. Other Methods of Binder Analysis

G. Binder Characterization and Comparison

VI. Pigment and Extender Examinations

A. Pigments and Extenders

B. Infrared Spectroscopy

C. Scanning Electron Microscopy/EDS

D. X-Ray Fluorescence Spectroscopy

E. X-Ray Diffraction Spectrometry

F. Elemental Compositional Comparisons

G. UV/VIS Microspectrophotometry

H. Other Methods of Analysis

VII. Additive Examinations

A. Types and Functions

B. Infrared Spectroscopy

C. Pyrolysis Gas Chromatography

D. Pyrolysis Gas Chromatography/Mass Spectrometry

E. Pyrolysis Mass Spectrometry

F. Scanning Electron Microscopy/EDS

G. X-Ray Fluorescence Spectroscopy

H. UV/VIS Microspectrophotometry

I. Other Methods of Analysis

VIII. Surface Effects

A. Weathering/Aging

B. Surface Protectants

C. Contaminants

IX. Significance and Interpretation

A. Presence of Paint

B. Type of Paint (Classification)

C. Discrimination

D. Report Writing

E. Testimony

X. Supervised Casework

XI. Final Evaluation