This document has been sent to **ASTM International** for development as an ASTM Standard. For information about ASTM and their process please refer to astm.org. This document is being made available at this stage of the process so that the forensic science community and interested stakeholders can be more fully aware of the efforts and work products of the Organization of Scientific Area Committees for Forensic Science (OSAC). The documents were prepared with input from OSAC Legal Resource Committee, Quality Infrastructure Committee, and Human Factors Committees, as well as the relevant Scientific Area Committee. The content of the documents listed below is subject to change during the standards development process within ASTM and may not represent the contents of the final published standard. All stakeholder groups or individuals are strongly encouraged to submit technical comments on this draft document during the ASTM balloting process. Technical comments will not be accepted if submitted to the OSAC Scientific Area Committee or Subcommittees.

Standard Practice for a Forensic Tape Analysis Training Program

OSAC
Organization of Scientific Area Committees for Forensic Science

Draft Document

Date: August 2018

To: Subcommittee E30.01 members

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Work Item #: WK64633

Ballot Action: Proposed new standard

Rationale: **The OSAC Materials (Trace) Subcommittee has developed a training document for the forensic analysis of tapes. This document was created through a consensus process. It is anticipated that the standard will be used by practitioners and laboratories to develop a training program for the forensic analysis of tape. Legal or scientific terms that are generally understood or defined adequately in other readily available sources may not be included in this standard. This is the first time this item has been balloted at the subcommittee level.**

Standard Practice for a Forensic Tape Analysis Training Program

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 on pressure sensitive tapes and adhesives. This standard cannot replace knowledge, skills, or abilities acquired through education, training, and experience and is to be used in conjunction with professional judgment by individuals with such discipline-specific knowledge, skills, and abilities.

1.2. It contains a list of training objectives with recommended methods of instruction, reading assignments and structured exercises to provide practical experience for the trainee.

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

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

1.2.3. Additional tape 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.

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

1.2.5. Tape samples are evaluated for physical matches of the cut or torn end pieces. This document does not provide training requirements for physical match comparisons. Additional training is required to conduct this type of analysis.

1.3. This document 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 with full citations are listed in each subsequent section of this document.

1.4. A tape training program provides a theoretical foundation and basic practical skills necessary to prepare a trainee to become a qualified forensic tape examiner. At the end of the tape training program, the trainee is capable of forming opinions based upon sound scientific knowledge, proper examinations,

and practical experience. The trainee also is able to independently work cases, write reports, testify in court, and peer review cases.

1.5. This standard practice does not address human factors (e.g. 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 ASTM E2917 Standard Practice for Forensic Scientist Practitioner Training, Continuing Education, and Professional Development Programs.

1.6. *This standard practice 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 limitations prior to use.*

2. Referenced Documents

2.1. ASTM E2917 Standard Practice for Forensic Scientist Practitioner Training, Continuing Education, and Professional Development Programs

2.2. ASTM E3085 Standard Guide for Using Fourier Transform Infrared Spectroscopy in Forensic Tape Examinations

2.3. ASTM E2224 Standard Guide for Forensic Analysis of Fibers by Infrared Spectroscopy

2.4. ASTM E2228 Standard Guide for Microscopical Examination of Textile Fibers

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 tape examination and comparison.

3.2. With successful completion of this tape training program, the trainee gains the theoretical knowledge and practical skills necessary to perform tape examinations and comparisons.

3.3. This training document covers a variety of instrumental methods which can be used in the analysis of tape. Not all laboratories will have access to all of the instrumentation.

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), or X-ray Diffraction (XRD).

4. Responsibilities

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

4.1.1. The trainee shall meet the objectives set forth in the training program.

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

4.2.1. Introducing the trainee to the relevant scientific literature, proper 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 tape evidence

4.2.4. Teaching case management

4.2.5. Fostering ethical and proper professional conduct

4.2.6. Teaching appropriate quality assurance and quality control procedures

4.2.7. Reviewing tests, practical exercises, and casework samples with trainee
4.2.8. Teaching expert testimony skills through moot court and/or observation
4.2.9. Monitoring the trainee's progress
4.3. Each laboratory is required to maintain:
4.3.1. An up-to-date training program
4.3.2. Documentation of training
4.3.3. Documentation of competency tests and proficiency tests

5. Syllabus

5.1. A tape training program provides the trainee theoretical knowledge and practical skills in examining, interpreting, reporting, testifying, and reviewing forensic tape 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 tape examiners
5.1.2.1. Lectures and discussions
5.1.2.2. Practical demonstration of basic skills
5.1.2.3. Casework
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
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 tape evidence. For new examiners with no previous training in microscopical or instrumental techniques, the expected training period is between twelve to eighteen months.

6. Tape Analysis Training Program Objectives

6.1. *Encountering Tape Evidence*
6.1.1. This section introduces the trainee to the types of cases and the various conditions (intact, partial, backing only, scrim only, adhesive only, etc.) in which tapes are encountered as physical evidence.
6.1.2. Types of tapes which could be encountered as evidence include duct tape, electrical tape, strapping tape, packaging tape, office tape, paper (masking) tape, medical tape, gaffer's tape, and other specialty pressure sensitive adhesive tapes.
6.1.3. Reading Assignments

6.1.3.1. Scientific Working Group for Materials Analysis (SWGMAT), "Guideline for Forensic Examination of Pressure Sensitive Tapes," *Journal of the American Society of Trace Evidence Examiners*, Vol. 3, Issue 1, 2012, pp. 2-20.

6.1.3.2. Choudhry, M. and Whritenour, R., "A New Approach to Unraveling Tangled Adhesive Tape for Potential Detection of Latent Prints and Recovery of Trace Evidence", *Journal of Forensic Sciences*, Vol. 35, No. 6, 1990, pp. 1373-1383.

6.1.3.3. Neel, N. and McIntyre, A., "The Effects of Cyanoacrylate Fuming and Fluorescent Dye Staining on Forensic Tape Analysis", *Journal of the American Society of Trace Evidence Examiners*, Vol. 1, Issue 2, 2010, pp. 127-136.

6.1.3.4. Campbell, B.M., "Separation of Adhesive Tapes", *Journal of Forensic Identification*, Vol. 41, Issue 2, 1991, pp. 102-106.

6.1.4. Practical Exercises

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

6.1.4.2. Demonstrate the ability to separate tape by different methods.

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 exercises by the trainer.

6.2. *Tape Terminology*

6.2.1. This section introduces the trainee to the following terms:

6.2.1.1. Adhesive

6.2.1.2. Additives

6.2.1.3. Backing

6.2.1.4. Backsizing

6.2.1.5. Calendering

6.2.1.6. Cellophane

6.2.1.7. Cellulose acetate

6.2.1.8. Crepe

6.2.1.9. Duct tape

6.2.1.10. Elastomer

6.2.1.11. Electrical tape

6.2.1.12. Fill yarns

6.2.1.13. Filament tape

6.2.1.14. Flatback

6.2.1.15. Machine direction

6.2.1.16. Masking tape

6.2.1.17. Migration

6.2.1.18. Nominal width

6.2.1.19. Packaging tape

6.2.1.20. Physical end match

6.2.1.21. Plain (simple) weave

6.2.1.22. Plasticizers
6.2.1.23. Polymer
6.2.1.24. Pressure sensitive adhesives (PSA)
6.2.1.25. Pressure sensitive tape (PST)
6.2.1.26. Prime coat
6.2.1.27. Reinforcement
6.2.1.28. Release coat
6.2.1.29. Scrim
6.2.1.30. Scrim Count
6.2.1.31. Strapping tape
6.2.1.32. Tack
6.2.1.33. Tackifier
6.2.1.34. Texturized yarn
6.2.1.35. Twisted yarn
6.2.1.36. Thickness
6.2.1.37. Warp yarns
6.2.1.38. Weft insertion
6.2.1.39. Weft yarns
6.2.1.40. Yarns

6.2.2. Reading Assignments

6.2.2.1. Scientific Working Group for Materials Analysis (SWGMAT), "Guideline for Forensic Examination of Pressure Sensitive Tapes," *Journal of the American Society of Trace Evidence Examiners*, Vol. 2, Issue 1, 2011, pp. 88-89.

6.2.2.2. Scientific Working Group for Materials Analysis (SWGMAT), "Guideline for Assessing Physical Characteristics in Forensic Tape Examinations," *Journal of the American Society of Trace Evidence Examiners*, Vol. 2, Issue 1, 2011, pp. 98-99.

6.2.2.3. Johnston, J., Pressure Sensitive Adhesive Tapes - A Guide to their Function, Design, Manufacture, and Use. Pressure Sensitive Tape Council, Northbrook, IL, 2003.

6.2.3. Practical Exercise

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. *Manufacturing Processes*

6.3.1. This section introduces the trainee to tape manufacturing processes.

6.3.2. Reading and Viewing Assignments

6.3.2.1. Johnston, J., Pressure Sensitive Adhesive Tapes - A Guide to their Function, Design, Manufacture, and Use. Pressure Sensitive Tape Council, Northbrook, IL, 2003, pp. 117-150.

6.3.2.2. Johnston, J., Manufacturing Methods. ASTEEtrace.org/Resources/Tape Subgroup

6.3.2.3. How Duck Tape is Made (internet video) https://youtu.be/fVpNteozrO0 [5/30/2017]

6.3.2.4. How It's Made Adhesive Tape (internet video) https://youtu.be/hr7yWWq5ZZs [5/30/2017]

6.3.3. The trainee is encouraged to visit tape manufacturing facilities.

6.3.4. The methods of instruction for this unit are reading and viewing relevant videos by the trainee.

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

6.4. *Overview of Forensic Tape Examinations*

6.4.1. This section introduces the trainee to the basic steps in forensic tape examinations.

6.4.2. Reading Assignments

6.4.2.1. Laboratory specific tape analysis procedure(s)

6.4.2.2. Bradley, M., Keagy, R., Lowe, P., Rickenbach, M., Wright, D., and LeBeau M., "A Validation Study for Duct Tape End Matches," *Journal of Forensic Sciences,* Vol. 51, No. 3, 2006, pp. 504-508.

6.4.2.3. Bradley, M., Gauntt, J., Mehltretter, A., Lowe, P., and Wright, D., "A Validation Study for Vinyl Electrical Tape End Matches," *Journal of Forensic Sciences,* Vol. 56, No. 3, 2011, pp. 606-611.

6.4.2.4. Mehltretter, A. and Bradley, M., "Forensic Analysis and Discrimination of Duct Tapes," *Journal of the American Society of Trace Evidence Examiners*, Vol. 3, Issue 1, 2012, pp. 2-20.

6.4.2.5. Smith, J., "Forensic Examinations of Pressure Sensitive Tape," *Forensic Analysis on the Cutting Edge - New Methods for Trace Evidence Analysis.* Blackledge, R.D., Editor, Wiley and Sons, Inc., 2007, Chapter 12, pp. 291-332.

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

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

6.5. *Examination of Physical Properties*

6.5.1. This section introduces the trainee to the physical properties of a variety of tapes to include the following:

6.5.1.1. Backing type (e.g. paper, polymer)

6.5.1.2. Backing properties such as color, texture, gloss, edge features, calendering marks, striations, pores/pits, and inclusions

6.5.1.3. Adhesive properties such as color, texture, and appearance

6.5.1.4. Width measurements

6.5.1.5. Overall thickness

6.5.1.6. Backing thickness

6.5.1.7. Scrim/yarn count

6.5.1.8. Backing construction (number of layers)

6.5.2. Reading Assignments

6.5.2.1. Scientific Working Group for Materials Analysis (SWGMAT), "Guideline for Assessing Physical Characteristics in Forensic Tape Examinations," *Journal of the American Society of Trace Evidence Examiners*, Vol. 2, Issue 1, 2011, pp. 98-105.

6.5.2.2. LaPorte, K. and Weimer, R., "Evaluation of Duct Tape Physical Characteristics: Part I – Within-Roll Variability," *Journal of the American Society of Trace Evidence Examiners*, Vol. 7, Issue 1, 2017, pp. 15-34.

6.5.3. Practical Exercise

6.5.3.1. Perform a comparison of the physical properties of several known tape samples.

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

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

6.6. *Microscopical Examination of Tape Components*

6.6.1. This section introduces the trainee to the microscopical characteristics of a variety of tapes.

6.6.2. Include the following points of instruction:

6.6.2.1. Determine backing and possible adhesive layer sequence using cross sectioning techniques

6.6.2.2. Compare backings and adhesives using polarized light microscopy (PLM)

6.6.2.3. Classify clear backed tapes as biaxially oriented polypropylene (BOPP) or monoaxially oriented polypropylene (MOPP) using polarizing techniques

6.6.3. Reading Assignments

6.6.3.1. Scientific Working Group for Materials Analysis (SWGMAT), "Guideline for Using Light Microscopy in Forensic Examinations of Tapes," *Journal of the American Society of Trace Evidence Examiners*, Vol. 2, Issue 1, 2011, pp. 106-111.

6.6.3.2. Smith, J. and Weaver, R., "PLM Examinations of Clear Polymer Films," *The Microscope*, 52, 2004, pp. 113-118.

6.6.3.3. Sakayanagi, M., Konda, Y., Watanabe, K., and Harigaya, Y., "Identification of Pressure Sensitive Adhesive Polypropylene Tape," *Journal of Forensic Sciences*, 48, 2003, pp. 68 – 76.

6.6.3.4. Goodpaster, J., Sturdevant, A., Andrews, K., and Brun-Conti, L., "Identification and Comparison of Electrical Tapes Using Instrumental and Statistical Techniques: I. Microscopic Surface Texture and Elemental Composition," *Journal of Forensic Sciences*, Vol. 52, No. 3, 2004, pp. 610-629.

6.6.3.5. Hobbs, A., Gauntt, J., Keagy, R., Lowe, P., and Ward, D., "A New Approach for the Analysis of Duct Tape Backings," *Forensic Science Communications*, 9 (1), 2007.

6.6.3.6. Stellmack, M. and Teetsov, A., "Hand-Sectioning and Identification of Pressure-Sensitive Tapes", *Modern Microscopy*, The McCrone Group, June 30, 2004, web Aug. 3, 2016.

6.6.3.7. Rappe, R., "Measurement of Principle Refractive Indices of Oriented Polymer Films" *The Microscope*, Vol. 35, 1987, pp. 67-82.

6.6.4. Practical Exercise

6.6.4.1. Compare the microscopical characteristics of a variety of types of tape (e.g. duct, electrical, packaging, office).

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

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

6.7. *Examination of Reinforcing Materials*

6.7.1. This section introduces the trainee to the reinforcing materials encountered in a variety of tapes.

6.7.2. Training for strapping (filament) tapes includes characterizing the general fiber types using PLM.

6.7.3. Training for fabric reinforced tapes (duct and gaffers) includes:

6.7.3.1. Performing scrim/yarn counts

6.7.3.2. Determining the weave of the scrim fabrics (e.g. weft insertion, plain weave)

6.7.3.3. Characterizing the yarns in the warp and fill directions (e.g. untwisted bundles, texturized groups, twisted bundles)

6.7.3.4. Determining yarn twist direction (e.g. Z, S, zero)

6.7.3.5. Observing the fluorescence of the fabric using long and short wave ultraviolet light and recording the fluorescence of the fibers composing the warp or fill yarns

6.7.3.6. Determining general fiber type(s) comprising warp and fill yarns using PLM or FTIR or both

6.7.4. If the trainee is not a fiber examiner, additional fiber identification training focusing on fibers encountered in tape reinforcement materials could be needed.

6.7.5. Reading Assignments

6.7.5.1. ASTM E2224 Standard Guide for Forensic Analysis of Fibers by Infrared Spectroscopy

6.7.5.2. ASTM E2228 Standard Guide for Microscopical Examination of Textile Fibers

6.7.5.3. Palenik, S., "Microscopical Examination of Fibres", *Forensic Examination of Fibres,* Robertson, J., Grieve, M., editors, London: Francis & Taylor, 1999, pp. 1-30, 156-170.

6.7.6. Practical Exercise

6.7.6.1. Compare the features of a variety of reinforcing materials in duct tape and strapping tape.

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

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

6.8. *Fourier Transform Infrared Spectroscopy (FTIR)*

6.8.1. This section introduces the trainee to the classification and comparison of a variety of tapes based on their chemical composition using FTIR.

6.8.2. Include the following points of instruction:

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

6.8.2.2. Preparing samples for analysis by FTIR

6.8.2.3. Performing computer searches of spectral libraries, if available

6.8.2.4. Classifying and comparing a variety of tape backings (classify polymer types).

6.8.2.5. Classifying and comparing a variety of tape adhesives (classify elastomer types).

6.8.2.6. Demonstrating familiarity with classes of adhesive tackifiers.

6.8.2.7. Demonstrating familiarity with extenders used in tape backings and adhesives.

6.8.2.8. Classifying general fiber types used in reinforcing fabrics.

6.8.2.9. Extracting and classifying plasticizers from PVC tape backings.

6.8.2.10. Understanding the strengths and limitations of the technique.

6.8.3. Reading Assignments

6.8.3.1. ASTM E3085 Standard Guide for Using Fourier Transform Infrared Spectroscopy in Forensic Tape Examinations

6.8.3.2. Merrill, R. and Bartick, E., "Analysis of Pressure Sensitive Adhesive Tape: I. Evaluation of Infrared ATR Accessory Advances," *Journal of Forensic Sciences,* Vol. 45, No. 1, 2000, pp. 93-98.

6.8.3.3. Johnston, J., *Pressure Sensitive Adhesive Tapes - A Guide to their Function, Design, Manufacture, and Use.* Pressure Sensitive Tape Council, Northbrook, IL, 2003, Chapters 3 - 6.

6.8.3.4. Goodpaster, J., Sturdevant, A., Andrews, K., Brinley, E., and Brun-Conti, L., "Identification and Comparison of Electrical Tapes Using Instrumental and Statistical Techniques: II. Organic Composition of the Tape Backing and Adhesive," *Journal of Forensic Sciences,* Vol. 54, No. 2, 2009, pp. 328-338.

6.8.4. Practical Exercise

6.8.4.1. Compare the chemical characteristics and classify the components in a variety of tapes (backings, adhesives, and reinforcing fabrics) using FTIR.

6.8.5. The methods of instruction for this unit are reading by the trainee and lecture from the trainer.
6.8.6. The method of evaluation for this unit is an evaluation of the practical exercise.

6.9. *Raman Spectroscopy*
6.9.1. This section introduces the trainee to the comparison of a variety of tape components based on their chemical composition using Raman spectroscopy.
6.9.2. Include the following points of instruction:
6.9.2.1. Understanding the theory of Raman spectroscopy (unless previously authorized to use the instrument)
6.9.2.2. Preparing samples for analysis by Raman spectroscopy.
6.9.2.3. Performing computer searches of spectral libraries, if available.
6.9.2.4. Using Raman to classify and compare backings and adhesives of tapes.
6.9.2.5. Understanding the strengths and limitations of the technique
6.9.3. Reading Assignments
6.9.3.1. Kuptsov, A., "Applications of Fourier Transform Raman Spectroscopy in Forensic Science", *Journal of Forensic Science*, Vol. 39, 1994, pp. 305-318.
6.9.3.2. Stoeffler, S.F., "The Use of Microscopical Methods for Characterization and Failure/Contamination Analysis of Adhesive Tapes," presented at the Tech XXV Meeting of the Pressure Sensitive Tape Council, Atlanta, Georgia, May 2002.
6.9.4. Practical Exercises
6.9.4.1. Prepare and analyze several backing and adhesive samples
6.9.4.2. Search a series of spectra against a spectral library.
6.9.4.3. Perform component classifications for the spectra of a series of unknown samples.
6.9.5. The methods of instruction for this unit are reading by the trainee and lectures and demonstrations from the trainer.
6.9.6. The method of evaluation for this unit is an evaluation of the practical exercises.

6.10. *Pyrolysis Gas Chromatography/Mass Spectrometry (PGC and PGC/MS)*
6.10.1. This section introduces the trainee to the comparison of a variety of tapes based on their chemical composition using pyrolysis gas chromatography with flame ionization detection (PGC) or pyrolysis gas chromatography/mass spectrometry (PGC/MS).
6.10.2. Include the following points of instruction:
6.10.2.1. Understanding the theory of PGC or PGC/MS (unless previously authorized to use the instrument)
6.10.2.2. Preparing samples for analysis by PGC or PGC/MS
6.10.2.3. Performing computer searches of spectral libraries, if available
6.10.2.4. Using PGC or PGC/MS to classify and compare polymers and plasticizers from tapes
6.10.2.5. Understanding the strengths and limitations of the technique
6.10.3. Reading Assignments
6.10.3.1. Scientific Working Group for Materials Analysis (SWGMAT), "Guideline for Using Pyrolysis-Gas Chromatography and Pyrolysis-Gas Chromatography/Mass Spectrometry in Forensic Tape Examinations," *Journal of the American Society of Trace Evidence Examiners*, Vol. 5, Issue 1, 2014, pp. 42-50.

6.10.3.2. Mehltretter, A., Bradley, M., and Wright, D., "Analysis and Discrimination of Electrical Tapes: Part II. Backings", *Journal of Forensic Sciences,* Vol. 56, No. 6, 2011, pp. 1493-1504.
6.10.3.3. Wampler, T., *Applied Pyrolysis Handbook,* 2nd ed.; Taylor & Francis Group: Boca Raton, FL., 2007.
6.10.3.4. Williams, E. and Munson T., "The Comparison of Black Polyvinylchloride (PVC) Tapes by Pyrolysis Gas Chromatography," *Journal of Forensic Sciences,* Vol. 33, No. 5, 1988, pp. 1163-70.
6.10.4. Practical Exercise
6.10.4.1. Compare the chemical characteristics in a variety of tapes (backings and adhesives) using PGC or PGC/MS.
6.10.5. The methods of instruction for this unit are reading by the trainee and lecture from the trainer.
6.10.6. The method of evaluation for this unit is a review of the practical exercise.

6.11. *Scanning Electron Microscopy/Energy Dispersive X-ray Spectrometry (SEM/EDS)*
6.11.1. This section introduces the trainee to the comparison of a variety of tapes based on their elemental components using SEM/EDS.
6.11.2. Include the following points of instruction:
6.11.2.1. Understanding the theory of SEM/EDS (unless previously authorized to use the instrument)
6.11.2.2. Preparing samples for analysis by SEM/EDS
6.11.2.3. Knowing the types of SEM detectors and understanding when each detector may be used
6.11.2.4. Performing computer searches of spectral libraries, if available
6.11.2.5. Demonstrating the ability to use the technique to compare samples based upon their elemental components
6.11.2.6. Understanding the strengths and limitations of the technique
6.11.3. Reading Assignments
6.11.3.1. Scientific Working Group for Materials Analysis (SWGMAT), "Guideline for Using Scanning Electron Microscopy/Energy Dispersive X-ray Spectrometry in Forensic Tape Examinations," *Journal of the American Society of Trace Evidence Examiners,* Vol. 2, Issue 1, 2011, pp. 122-132.
6.11.3.2. Goodpaster, J., Sturdevant, A., Andrews, K., and Brun-Conti, L., "Identification and Comparison of Electrical Tapes Using Instrumental and Statistical Techniques: I. Microscopic Surface Texture and Elemental Composition," *Journal of Forensic Sciences,* Vol. 52, No. 3, 2007, pp. 610-629.
6.11.3.3. Mehltretter, A., Bradley, M., and Wright, D., "Analysis and Discrimination of Electrical Tapes: Part I. Adhesives", *Journal of Forensic Sciences,* Vol. 56, No. 1, 2011, pp. 82-94.
6.11.3.4. Mehltretter, A., Bradley, M., and Wright, D., "Analysis and Discrimination of Electrical Tapes: Part II. Backings", *Journal of Forensic Sciences,* Vol. 56, No. 6, 2011, pp. 1493-1504.
6.11.3.5. Jenkins, T., "Elemental Examination of Silver Duct Tape Using Energy Dispersive X-Ray Spectrometry," ASTEEtrace.org/Resources/Tape Subgroup
6.11.4. Practical Exercise
6.11.4.1. Compare the elemental characteristics in a variety of tapes (backings and adhesives) using SEM/EDS.
6.11.5. The methods of instruction for this unit are reading by the trainee and lecture from the trainer.
6.11.6. The method of evaluation for this unit is a review of the practical exercise.

6.12. *X-ray Fluorescence Spectroscopy (XRF)*

6.12.1. This section introduces the trainee to the comparison of a variety of tapes based on their elemental components using XRF.

6.12.2. Include the following points of instruction:

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

6.12.2.2. Preparing samples for analysis by XRF

6.12.2.3. Performing computer searches of spectral libraries, if available

6.12.2.4. Demonstrating the ability to use the technique to compare samples based upon their elemental components

6.12.2.5. Understanding the strengths and limitations of the technique

6.12.3. Reading Assignments

6.12.3.1. Jenkins R., Buhrke, V., Smith, D., editors. *A Practical Guide for the Preparation of Specimens for X-Ray Fluorescence and X-Ray Diffraction Analysis*, Wiley-VCH, New York, 1998.

6.12.3.2. Keto, R., "Forensic Characterization of Black Polyvinyl Chloride Electrical Tape", *Crime Laboratory Digest*, Vol. 11, No. 4, October 1984.

6.12.4. Practical Exercise

6.12.4.1. Compare the elemental characteristics in a variety of tapes (backings and adhesives) using XRF.

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

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

6.13. *X-ray Diffraction (XRD)*

6.13.1. This section introduces the trainee to the comparison of a variety of tapes based on their diffraction pattern using XRD.

6.13.2. Include the following points of instruction:

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

6.13.2.2. Preparing samples for analysis by XRD

6.13.2.3. Performing computer searches of diffractograms, if available

6.13.2.4. Demonstrating the ability to use the technique to compare samples based upon their diffraction patterns

6.13.2.5. Understanding the strengths and limitations of the technique

6.13.3. Reading Assignments

6.13.3.1. Jenkins, R., Buhrke, V., Smith, D., editors. *A Practical Guide for the Preparation of Specimens for X-Ray Fluorescence and X-Ray Diffraction Analysis*, Wiley-VCH, New York, 1998.

6.13.3.2. Mehltretter, A. and Bradley, M., "Forensic Analysis and Discrimination of Duct Tapes," *Journal of the American Society of Trace Evidence Examiners*, Vol. 3 Issue 1, 2012, pp. 2-20.

6.13.3.3. Turley, J., *X-Ray Diffraction Patterns of Polymers*, International Centre for Diffraction Data, Newtown Square, PA, 1965.

6.13.3.4. Wright, D. and Mehltretter, A., "Forensic Duct Tape Sourcing Examinations: Developing Investigative Leads Using Multiple Resources," *Journal of the American Society of Trace Evidence Examiners*, Vol. 4, Issue 1, 2013, pp. 13-28.

6.13.4. Practical Exercise

6.13.4.1. Compare the diffraction patterns in a variety of tapes (backings and adhesives) using XRD.

6.13.5. The methods of instruction for this unit are reading by the trainee and lecture from the trainer.
6.13.6. The method of evaluation for this unit is a review of the practical exercise.

6.14. *Microspectrophotometry (MSP)*
6.14.1. This section introduces the trainee to the comparison of tape samples using MSP.
6.14.2. Include the following points of instruction:
6.14.2.1. Understanding the theory of MSP (unless previously authorized to use the instrument)
6.14.2.2. Preparing samples for analysis by MSP.
6.14.2.3. Demonstrating the ability to use the technique to compare spectra.
6.14.2.4. Understanding the strengths and limitations of the technique.
6.14.3. Reading Assignments
6.14.3.1. Maynard, P., Gates, K, Roux, C., and Lennard, C., "Adhesive Tape Analysis: Establishing the Evidential Value of Specific Techniques," *Journal of Forensic Sciences,* Vol. 46, No. 2, 2001, pp. 280-287.
6.14.3.2. Reffner, J., "Microspectroscopy in Forensic Science", *Encyclopedia of Analytical Chemistry,* 2017, pp. 1–17.
6.14.3.3. Craic Technologies, "Analysis of Tape Used in Improvised Explosive Devices (IED) Using Microspectrophotometry", June 2, 2011, http://www.azom.com/article.aspx?ArticleID=5694 [August 4, 2017].
6.14.4. Practical Exercise
6.14.4.1. Compare the spectra from a variety of tape samples using MSP.
6.14.5. The methods of instruction for this unit are reading by the trainee and lecture from the trainer.
6.14.6. The method of evaluation for this unit is a review of the practical exercise.

6.15. *Comparison and Discrimination of Tape*
6.15.1. This section introduces the trainee to the comparison of a variety of tapes based on their physical and chemical characteristics.
6.15.2. Include the following points of instruction:
6.15.2.1. Assessing the comparison results and attaching significance to those results
6.15.2.2. Defining and recognizing meaningful differences.
6.15.2.3. Explaning the discrimination power of the analytical protocol used.
6.15.3. Reading Assignments
6.15.3.1. Goodpaster, J., Sturdevant, A., Andrews, K., and Brun-Conti, L., "Identification and Comparison of Electrical Tapes Using Instrumental and Statistical Techniques: I. Microscopic Surface Texture and Elemental Composition," *Journal of Forensic Sciences,* Vol. 52, No. 3, 2007, pp. 610-629.
6.15.3.2. Goodpaster, J., Sturdevant, A., Andrews, K., Briley, E., and Brun-Conti, L., "Identification and Comparison of Electrical Tapes Using Instrumental and Statistical Techniques: II. Organic Composition of the Tape Backing and Adhesive," *Journal of Forensic Sciences,* Vol. 54, No. 2, 2009, pp. 328-338.
6.15.3.3. Maynard, P., Gates, K., Roux, C., and Lennard, C., "Adhesive Tape Analysis: Establishing the Evidential Value of Specific Techniques," *Journal of Forensic Sciences,* Vol. 46, No. 2, 2001, pp. 280-287.

6.15.3.4. Mehltretter, A. and Bradley, M., "Forensic Analysis and Discrimination of Duct Tapes," *Journal of the American Society of Trace Evidence Examiners*, Vol. 3 No. 1, 2012, pp. 2-20.
6.15.3.5. Mehltretter, A., Bradley, M., and Wright, D., "Analysis and Discrimination of Electrical Tapes: Part I. Adhesives", *Journal of Forensic Sciences,* Vol. 56, No. 1, 2011, pp. 82-94.
6.15.3.6. Mehltretter, A., Bradley, M., and Wright, D., "Analysis and Discrimination of Electrical Tapes: Part II. Backings", *Journal of Forensic Sciences,* Vol. 56. No. 6, 2011, pp. 1493-1504.
6.15.3.7. Mehltretter, A., Wright, D., Dettman, J., and Smith, M., "Intra-Roll and Intra-Jumbo Roll Variation of Duct Tapes," *Journal of the American Society of Trace Evidence Examiners*, Vol. 6 No. 1, 2015, pp. 21-41.
6.15.3.8. Mehltretter, A., Wright, D., and Smith, M., "Variation in Duct Tape Products Over Time: Physical Measurements and Adhesive Compositional Analysis by Fourier Transformed Infrared Spectroscopy", *Journal of Forensic Chemistry*, Vol. 4, 2017, pp. 1-8.
6.15.3.9. Robertson, B., Vignaux, G., and Berger, C., *Interpreting Evidence: Evaluating Forensic Science in the Courtroom*, 2nd ed., Wiley Publishers, 2016.
6.15.4. Practical Exercise
6.15.4.1. Complete comparisons and summarize the completed practical exercise sets utilized in previous instruction.
6.15.5. The methods of instruction for this unit are reading by the trainee and lecture from the trainer.
6.15.6. The method of evaluation for this unit is a review of the practical exercise.

6.16. *Report Writing*
6.16.1. This section introduces the trainee to writing technically and administratively accurate reports for forensic tape examinations.
6.16.2. Reading Assignment
6.16.2.1. Laboratory specific tape analysis procedure(s) on reporting.
6.16.3. Practical Exercise
6.16.3.1. Write reports for the previously completed practical exercises.
6.16.4. The methods of instruction for this unit are reading completed technically reviewed reports and lecture from the trainer.
6.16.5. The method of evaluation for this unit is a review of the reports written by the trainee.

6.17. *Testimony*
6.17.1. This section introduces the trainee to testimony in forensic tape analysis.
6.17.2. Reading Assignments
6.17.2.1. Scientific Working Group for Materials Analysis (SWGMAT), "Tape Admissibility Package," at ASTEEtrace.org/Resources/Tape Subgroup
6.17.2.2. Daubert v. Merrell Dow Pharmaceuticals (92-102), 509 U.S. 579 (1993)
6.17.2.3. Frye v. United States 293 F. 1013 (D.C. Cir. 1923)
6.17.2.4. Kumho Tire Co. v. Carmichael 526 US 137 (1999)
6.17.3. Practical Exercises
6.17.3.1. Prepare a list of suggested questions and a sheet of educational questions and answers for the court.
6.17.3.2. Review relevant materials for an admissibility hearing.

6.17.4. The methods of instruction for this unit are lecture from the trainer and viewing court testimony (if possible).
6.17.5. The method of evaluation for this unit is a review of the court documents prepared by the trainee.

6.18. *Final Training Evaluations*
6.18.1. This section evaluates the knowledge, skills, and abilities of the trainee through the following methods:
6.18.1.1. Completing a final comprehensive written or oral examination on forensic tape examinations.
6.18.1.2. Conducting mock case(s) for competency evaluation.
6.18.1.3. Participating in a mock trial using one of the mock cases completed during training. If the trainee has previous mock trial or court experience, an oral review may replace the mock trial.
6.18.2. The method of evaluation for this unit is a passing grade on the written examination, successful completion of the competency evaluation, and successful completion of the mock trial or oral review.

6.19. *Supervised Casework and Peer Reviews*
6.19.1. This section introduces the trainee to performing independent casework as well as technical and administrative peer reviews.
6.19.2. Practical Exercises:
6.19.2.1. Observe an experienced examiner perform casework.
6.19.2.2. Perform actual casework under the supervision of a qualified examiner before performing independent casework.
6.19.2.3. Complete mock technical and administrative review exercises.
6.19.3. The methods of instruction for this unit are demonstration by the trainer and discussion with the trainee.
6.19.4. The methods of evaluation for this unit are evaluation of the casework with no technical errors and minimal administrative errors and evaluation of the peer reviews completed by the trainee.

7. Keywords
7.1 forensic science; training; tape; tape analysis; trace; materials