Physical Examinations of Tape Evidence

1 Scope

This procedure applies to Chemistry Unit caseworking personnel who conduct physical examinations that are used to characterize and compare a variety of tape specimens.

2 Equipment/Materials/Reagents

a. Stereo microscope (~6X to ~50X magnification) with appropriate light source (e.g., annular ring light, fiber optic light)

b. Compound microscope (~35X to ~400X magnification) with appropriate light source

c. Ultraviolet light with long wavelength (~365nm) source

d. Cold source (e.g., liquid nitrogen, freezer)

e. Heat source (e.g., air dryer, heat lamp)

f. Scalpel handle with blades

g. Single edge razor blades

h. Probes (e.g., steel, tungsten, wood, Teflon™)

i. Digital micrometer, 0-1" range

j. Ruler with metric (1 mm) and/or English (1/64") graduations

k. Tweezers

l. Glass microscope slides

m. Disposable wipes

n. Cotton swabs

o. Thin-layer chromatography glass chamber, or equivalent, with lid

p. Acetone (Reagent grade)

q. Hexane (Reagent grade)

r. Methanol (Reagent grade)

s. Chloroform (Reagent grade)

t. Eyedropper bottles and/or disposable pipettes

u. Heavy-gauge transparency film or KAPAK® tubular rollstock

v. Munsell Neutral Value Scale and Soil Color Charts available from the Macbeth Division of Kollmorgen Instruments Corporation, New Windsor, NY

w. Polarizing light microscope (PLM) with a quarter wave or full wave plate

x. Digital camera

y. Digital microscope

3 Standards and Controls

Not applicable.

4 Sample Selection

Refer to the Paints and Polymers Standard Operating Procedure (P&P SOP) *General Approach for Tape Casework* for guidance on sample(s) selection. Record the samples selected for analysis in the case notes.

5 Procedure

If the tape evidence is received as a tangled mass or a series of overlapping strips, separate, flatten, and arrange each piece on heavy-gauge transparency film (or equivalent clear, colorless plastic sheets) for comparison of physical properties. Vinyl plastic document protectors are <u>not</u> suitable due to the presence of volatile plasticizers (e.g., phthalates) within their matrix, which can migrate into the adhesive layer of the tape; however, clear and colorless plastic evidence storage bags (e.g., KAPAK®) are acceptable.

Tape specimens that are wadded together or overlapped require special attention in order to free the adhesive layers. Suggested methods to aid in the separation are described below and should

be ordered to minimize alteration of the items received (e.g., adhesive removal, fabric or backing distortion, damage to the free ends).

A. Gently heat the tape with an air dryer while applying tension on opposite sides of the wadded area in order to gradually reduce the tack of the adhesive without tearing or distortion of the tape during manipulation.

B. Fill a porcelain dish or crucible with liquid nitrogen and immerse the tape for approximately one minute. If freezing does not enable quick and easy unpeeling, attempt this process a second time before trying another separation technique. Alternatively, the tape can be placed in an evidence freezer overnight (under proper seal and appropriately labeled).

C. If the tape is so entwined as to risk damage or tearing with the methods mentioned above, suspend the mass in a thin layer chromatography tank along with approximately 100 mL of chloroform (in two 50 mL beakers placed at opposite ends of the tank with the wadded tape in between). Cover the appropriately-labeled tank, and place it under proper seal in a fume hood for several hours or overnight. The solvent-saturated atmosphere should reduce the tack of the adhesive to facilitate separation and flattening of the pieces.

D. Under a vented fume hood, apply an appropriate solvent drop wise to the edges of a wadded area or adhesive/substrate interface and gently pry the edges apart. Initially employ a mild solvent (e.g., hexane for rubber-based adhesives or acetone for acrylic-based adhesives). If a more aggressive solvent is required, chloroform can be used. Moderate heating can be helpful in conjunction with the solvent application.

Use written descriptions, sketches, photography, or other imaging methods to capture both macroscopical and microscopical characteristics and observations. A flow chart of the physical examinations used to conduct a tape comparison is provided in Figure 1. The discrimination value of the physical characteristics depends on the type and condition of the tape. Therefore, the order of the examinations depicted in Figure 1 is left to the discretion of the examiner.

1) Observe the separate components of the tape specimen using both the unaided eye and a stereo microscope with ~6X to ~50X magnification.

    a) Adhesive Examinations.

        i) Record observations regarding the adhesive color. Provided color attributes have not been obscured by environmental effects or previous forensic examinations (e.g., weathering, latent fingerprint processing), differences will quickly disassociate items of evidence. Important distinctions include a clear, colorless adhesive versus a black adhesive on vinyl electrical tape, or a tan adhesive versus a clear, colorless adhesive

on brown packaging tape. Duct tape adhesive color comparisons can be facilitated using the matte version of the Munsell Neutral Value Scale or Soil Color Charts.

b) Backing Examinations.

i) Record observations describing the tape backings such as color, degree of gloss, texture, or fabrication markings. If necessary, clean the tape backing with a mild solvent (e.g., methanol, water) and a cotton swab. Evaluate the layer structure of a duct tape backing. This can be accomplished by freezing the backing to ensure rigidity, taking a cross-section with a single-edged razor blade, and viewing the cross-section in transmitted light with a compound or digital microscope.

ii) Tape width is another possible point of comparison between full width specimens. Measure and record the observed widths to the nearest $^{1}/_{64}$" or 0.5 mm using a ruler. A simple observation is often all that is needed when widths are different (e.g., 2" versus 3" wide duct tape). Additionally, some tapes will permanently deform when stretched, torn, or stressed. Therefore, only conduct width measurements on items that do not appear to have been severely distorted or degraded.

iii) Overall tape and backing thicknesses are other possible points of comparison between specimens. Observe differences between thicknesses using transmitted light microscopy of tape cross-sections with a common scale/magnification. Alternatively, measure thicknesses using a micrometer. If measurements are performed, take a minimum of three measurements along a representative sample, and record these values to the nearest 0.00005" along with the manufacturer and ID number of the micrometer. For backing thicknesses, remove adhesives prior to measurement. Only conduct thickness measurements on items that do not appear to have been severely distorted, degraded, or contaminated.

iv) If the backing is a clear, colorless polymeric film, affix a sample to a glass microscope slide oriented with the machine direction parallel to the edge of the slide. Observe the tape under a PLM using crossed polars and compare the extinction angle and birefringence colors.

c) Fabric Examinations.

i) Tape samples containing fiber or fabric reinforcement can be differentiated based on several factors: yarn count, yarn composition and construction, and fabric weave. To expose the fabric or fiber reinforcement, remove rubber-based adhesives with hexane or chloroform; remove acrylic-based adhesives with acetone.

(1) Determine the weave pattern and a general description of the warp and fill yarns. Plain weave and weft-insertion are common examples of fabrics encountered in

duct tape samples. Record the weave and yarns in the case notes (e.g., description, sketch, photocopy, photograph).

(2) Determine the number of yarns in a one square inch section of the tape in both the machine direction (m.d., warp) and cross direction (c.d., fill). If the sample is large enough, consider taking repeat measurements. If the sample is limited in size, calculate the yarn count in the machine and/or cross direction on an area less than one inch. Record the area measured in the case notes.

(3) Determine and record whether yarns in the machine and/or cross directions fluoresce under UV exposure at ~365 nm.

(4) If two or more tape samples have not been discriminated at the conclusion of all examinations, forward samples containing fabric or glass filament reinforcement to the appropriate personnel for additional testing. Those results will be provided in a separate Laboratory Report by the assigned examiner, but P&P personnel should disclose the additional (pending) tape exams.

2) Examine tape evidence for possible end matches between specimens.

a) If a possible end match is observed, examine the tear pattern from the backing and adhesive sides of both specimens with the aid of a stereomicroscope to determine whether an end match remains plausible.

b) If the backing is distorted or folded over and adhered to the adhesive layer, carefully straighten it out to restore the edge. This can be facilitated with the use of tweezers, heat, or mild solvent.

c) Determine if there are individualizing characteristics such as a defect in the backing or in the fabric reinforcement that extends across the fracture. The beginning and end point of the defect must be apparent on both specimens to ensure that it is not continuous along the entire roll of tape.

d) If the tape has fiber or fabric reinforcement, use an appropriate solvent to remove enough of the adhesive layer to expose the reinforcing yarns. Ensure that the yarns in the machine (and if present, fill) direction line up along the fracture.

e) Depending on the type of tape, fabrication marks such as striations from extruders or embossed marks from calendar rolls can align across fractured edges providing additional features to corroborate an end match.

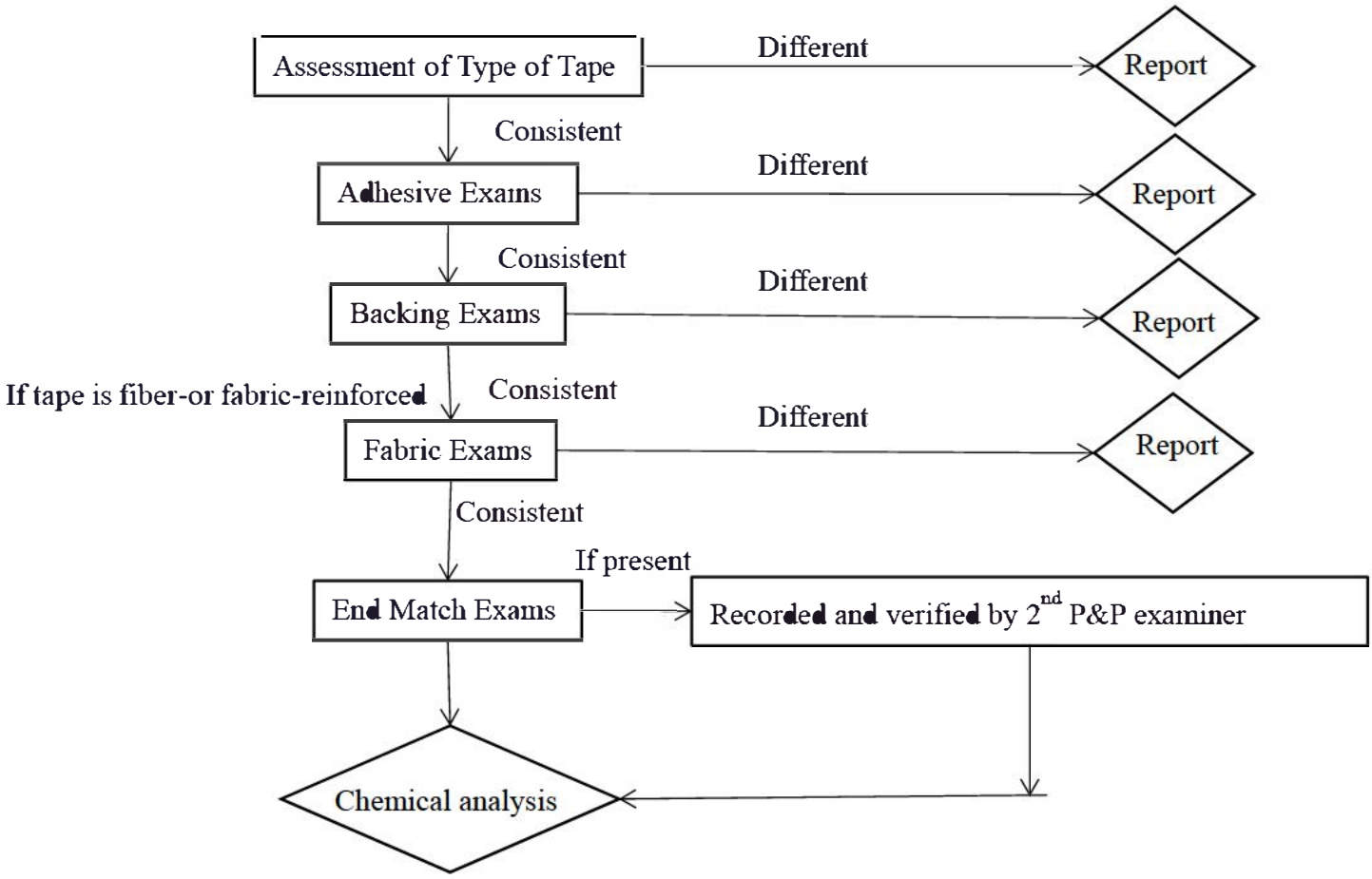
f) Record any end matches with descriptive notes.

g) A second P&P examiner must verify and record suspected fracture matches between known and question specimens. This confirmation can occur before or after the end matches are imaged with a measuring scale. In the case of fabric-reinforced tapes, include a diagram or map of the severed yarns to illustrate each complementary pair of warp yarns rejoining along a common margin at the fracture.

h) Unless deemed necessary based on case details, a second P&P examiner does not need to confirm end matches that are observed within an item or between items from the same location. This step is therefore disregarded in Figure 1. Furthermore, one piece of the reconstructed strip can be used for the remaining examinations.

3) If all physical characteristics are consistent between specimens being compared, proceed with instrumental examinations according to the applicable P&P SOPs.

Figure 1. Basic Approach to Physical Examinations of Tape Specimens



6 Decision Criteria

a. If physical characteristics of two specimens being compared differ, cease examinations and report that the specimens are different.

b. Since width and thickness are known to vary along the length of a roll of tape, exercise caution when minor differences are observed between samples (e.g., ±1.0 mm or ±10%, respectively).

c. According to duct tape industry contacts, a yarn count variation of ±1 yarn in either or both directions is acceptable within-roll variation.

d. Decision criteria for a tape end match are described in section 5, step 2.

7 Calculations

Not applicable.

8 Measurement Uncertainty

Not applicable.

9 Limitations

a. Sample size and condition can preclude conducting certain examinations.

b. Color, width, thickness, and/or scrim count assessments can be affected by sample condition.

c. In the absence of an end/fracture match, a tape specimen cannot be definitively associated to a particular roll of tape.

10 Precautionary Statement

As with any procedure involving trace evidence, ensure actions minimize the potential damage to the sample, particularly with respect to tearing or distorting of the tape ends.

11 Safety

Use standard precautions for the handling of potentially biohazardous materials, chemicals (including liquid nitrogen), and sharps. Refer to the *FBI Laboratory Safety Manual* for guidance.

12 References

Agron N, Schecter B. Physical comparisons and some characteristics of electrical tape. *AFTE J* 1986; 18:53-9.

Blackledge, R.D. Tapes with adhesive backings: Their characterization in the forensic science laboratory. In: *Applied Polymer Analysis and Characterization: Recent Developments in Techniques, Instrumentation, Problem Solving*. J. Mitchell, Jr, Ed. Carl Hanser Verlag, Munich, 1987; 413-421.

Bradley, M.J., Gauntt, J., Mehltretter, A.H., Lowe, P.C., and Wright, D.M. A validation study for vinyl electrical tape end matches. *J Forensic Sci* 2011, 56(3): 606-611.

Bradley, M.J., et al. A validation study of physical associations of duct tape ends. *J Forensic Sci* 2006; 51(3):504-508.

Courtney, M. Evidential examinations of duct tape. *J SWAFS,* April 1994;16(1):10-16.

FBI Laboratory Safety Manual

General Approach for Tape Casework, FBI Laboratory, Chemistry Unit – Paints and Polymers SOP

Goodpaster JV, Sturdevant AB, Andrews KL, Brun-Conti L. Identification and comparison of electrical tapes using instrumental and statistical techniques: I. Microscopic surface texture and elemental composition. *J Forensic Sci* 2007;52:610-29.

Hobbs, A., Gauntt, J., Keagy, R., Lowe, PC., and Ward, D. A new approach for the analysis of duct tape backings. *Forensic Science Communications*, 2007; 9(1).

Johnston, J. *Pressure Sensitive Adhesive Tapes,* Pressure Sensitive Tape Council, Northbrook, IL, 2000.

Johnston, J. and Serra, J. The examination of pressure sensitive adhesive tapes. *IAMA Newsletter* 2005;5:19-31.

Johnston, J. Duct Tape: Part II – Its examination and analysis. *SWAFS Journal* Aug 2006:7-14.

Kee, T.G. The characterization of PVC adhesive tape. *Proceedings of the International Symposium on the Analysis and Identification of Polymers*, FBI Academy, Quantico, VA, July 31- August 2, 1984, 77-85.

Keto, R.O. Forensic characterization of black polyvinyl chloride electrical tape. *Proceedings of the International Symposium on the Analysis and Identification of Polymers*, FBI Academy, Quantico, VA, July 31- August 2, 1984, 77-85.

Maynard, P., et al. Adhesive tape analysis: establishing the evidential value of specific techniques. *J. Forensic Sci.* 2001; 46(2): 280-287.

Mehltretter, A.H., Bradley, M.J. Forensic analysis and discrimination of duct tapes, *Journal of the American Society of Trace Evidence Examiners*, 2012, 3(1): 2-20.

Mehltretter, A.H., Bradley, M.J,. Wright, D.M. Analysis and discrimination of electrical tapes: Part I. Adhesives, *J Forensic Sci.*, 2011, 56(1): 82-94

Mehltretter, A.H., Bradley, M.J., Wright, D.M. Analysis and discrimination of electrical tapes: Part II. Backings, *J Forensic Sci.*, 2011; 56(6): 1493-1504

Mehltretter, A.H., Wright, D.M., Dettman, J.R., and Smith, M.A., and Intra-Roll and Intra-Jumbo Roll Variation of Duct Tapes, *Journal of the American Society of Trace Evidence Examiners*, 2015, 6(1): 21-41.

Mehltretter, A.H., Wright, D.M., and Smith, M.A. Variation in duct tape products over time: Physical measurements and adhesive compositional analysis by Fourier transform infrared spectroscopy, *Forensic Chemistry*, June 2017, 4: 1-8.

Pressure Sensitive Tape Council. Glossary of Terms Used in the Pressure Sensitive Tape Industry *Test Methods for Pressure Sensitive Tapes*, 10th ed., Northbrook, IL, 1992.

Rappe, R. Measurement of the principal refractive indices of oriented polymer films *Microscope*, 1987; 35: 67-81

Rappe, R. Microscopical examination of polymer films. *Microscope*, 1992; 40: 93-101.

Scientific Working Group for Materials Analysis (SWGMAT). Guideline for the Forensic Examination of Pressure-Sensitive Tapes. *Forensic Science Communications*, 2008; 10(4)

Scientific Working Group on Materials Analysis (SWGMAT), Guideline for Assessing Physical Characteristics in Forensic Tape Examinations, Online, Available: http://www.asteetrace.org (JASTEE, Vol 5., Issue 1, January 2014).

Scientific Working Group on Materials Analysis (SWGMAT), Guideline for Using Light Microscopy in Forensic Examinations of Tape Components, Online, Available: http://www.asteetrace.org (JASTEE, Vol 5, Issue 1, January 2014).

Smith, J. Forensic examination of pressure sensitive tape. In: *Forensic Analysis on the Cutting Edge: New Methods for Trace Evidence Analysis.* R. Blackledge, Ed. John Wiley and Sons, New York, 2007, 291-332.

Smith, J., and Weaver, R. PLM examinations of clear polymeric films: identification of monoaxial and biaxial orientation and other observations. *Microscope*, 2004; 52(3/4): 112-118.

Smith, J. The forensic value of duct tape comparisons. *Midwestern Association of Forensic Scientists, Inc. Newsletter*, January 1998; 27(1): 28-33.

Tulleners, FA, Braun JV. The Statistical Evaluation of Torn and Cut Duct Tape Physical End Matching. NIJ Award No, 2009-DN-BX-K235. Available: https://www.ncjrs.gov/pdffiles1/nij/grants/235287.pdf

Weaver, R. Rediscovering polarized light microscopy. *IAMA Newsletter*, 2005; 5(1):32-38.

Rev. #	Issue Date	History
0	06/21/06	New document that replaces previous document also titled *Macroscopic and Microscopic Examination of Tape Evidence*.
1	09/30/09	Changed the sampling plan guidelines and updated references.
2	02/27/12	Updated microscopic and macroscopic to microscopical and macroscopical where appropriate throughout document. Added digital microscope to section 5. Changed "sampling" plan to "sample selection" plan in Section 8. Clarified end match procedure in Section 9, step 5f. Changed thickness measurement decision criteria in Section 10. Updated references.
3	12/23/13	Changed title. Section 9 has been reordered and Figure 1 revised. Procedures for taking width and thickness measurements have been changed in Section 9 and statistical evaluations of same have been removed from Sections 10 and 11. Section 10 has also been edited to include width and thickness variations along the length of a roll of tape. References updated. Other minor editorial changes made throughout.
4	09/18/18	Deleted Introduction, Principle and Specimens sections as they did not describe procedural content and renumbered. Modified scope, updated section titles as needed to reflect LOM or practice changes, minor grammatical edits for clarification throughout (document changed to record), and updated references.
5	07/23/19	Removed requirement to record date of calibration of micrometer; minor grammatical corrections to comply with other quality system documents (e.g., confirm to verify, documented to recorded).

Approval

Redacted - Signatures on File

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