Guideline for Assessing Physical Characteristics in Forensic Tape Examinations

Scientific Working Group for Materials Analysis (SWGMAT)

1.0 Scope

This document is part of a series of SWGMAT guidelines relating to the forensic analysis of tape and is intended to assist individuals and laboratories that conduct physical examinations and comparisons of pressure sensitive tapes. Its aim is to provide a description of the methods used to assess the physical characteristics of tape evidence.

2.0 Reference Documents

ASTM International Standards

D1535 *Standard Practice for Specifying Color by the Munsell System*
E308 *Standard Practice for Computing the Colors of Objects by using the CIE System*
E1459 *Standard Guide for Physical Evidence Labeling and Related Documentation*
E1492 *Standard Practice for Receiving, Documenting, Storing, and Retrieving Evidence in a Forensic Science Laboratory*

SWGMAT Trace Evidence Quality Assurance Guidelines (January 1999). Available: http://swgmat.org/Trace%20Evidence%20Quality.pdf

SWGMAT Trace Recovery Guidelines (January 1998). Available: http://swgmat.org/Trace%20Evidence%20Recovery%20Guidelines.pdf

SWGMAT Forensic Fiber Documents. Available: http://swgmat.org/fiber.htm

SWGMAT Guideline for the Forensic Examination of Pressure-Sensitive Tapes (August 2007). Available: http://swgmat.org/Pressure%20Sensitive%20Tape%20guideline.pdf

3.0 Terminology

Adhesive: A material that will hold two or more objects together solely by intimate surface contact

Backing: A thin flexible material to which the adhesive is applied

Calendering: The use of a multi-roll device that uses heat and pressure to apply adhesive to a tape backing

Duct tape: Fabric-reinforced tape used for general utility applications

Electrical tape: Polyvinyl chloride (PVC)-backed tape with specific dielectric properties designed for electrical applications

Fill yarn: Yarns in the scrim fabric of reinforced tape that run crosswise, perpendicular to the warp direction; also referred to as weft yarns

Filament tape: A fiber-reinforced tape in which the reinforcing fibers are only in the warp direction; also referred to as strapping tape

Long-wave UV illumination: In the wavelength range from 400 nm – 315 nm with peak wavelength energy at 366 nm

Machine direction: The direction of the tape that runs the length of the tape

Masking tape: Paper-backed tape having a creped, usually beige or buff-colored backing. Painter's tape is a type of masking tape available in a number of colors.

Nominal width: The design width of the tape, usually in terms of round numbers. Measured width can vary slightly from nominal width.

Packaging tape: a) Pressure-sensitive tape consisting of an oriented polymer with a brown or clear adhesive layer, or b) Paper-backed tape, which has a moistenable adhesive

Physical end match: A one-of-a-kind fit between two pieces of torn or cut ends demonstrating that the two pieces were once one continuous piece.

Scrim: A loosely-woven gauze-type cloth added to duct tape for reinforcement and strength

Scrim count: The dimensional count of the scrim, in terms of yarns per inch, expressed as warp count by fill count

Short-wave UV illumination: In the wavelength range from 280 nm –100 nm with the peak wavelength energy at 254 nm

Stereomicroscope: A microscope containing two separate optical systems, one for each eye, giving a stereoscopic view of a specimen

Strapping tape: See filament tape.

Texturized yarn: Crimped reinforcement fibers designed to give bulk

Twist: The direction of twist in yarns is indicated by the capital letters S and Z. Yarn has an S-twist if when it is held vertically, the spirals around its central axis slope in the same direction as the middle portion of the letter S, and Z-twist if they slope in the same direction as the middle portion of the letter Z.

Warp yarns: Yarns in scrim fabric of reinforced tape that run lengthwise (in the machine direction)

Weft yarns: See fill yarns.

Yarn: For the purposes of this document, yarns refer to lengths of fiber reinforcement: twisted staple fibers or filament fibers.

4.0 Summary of Guideline

Tape specimens can be examined to determine a common source or possible manufacturer. This guide covers visual and stereomicroscope examinations for color, thickness, reinforcement, and backing and adhesive features. Structural details, such as design, construction, and composition, can provide information that may assist the analyst in reaching a conclusion.

A goal of a tape comparison is to assess the significance of any observed differences. If no significant physical differences are found between samples, instrumental analyses are warranted.

5.0 Significance and Use

Physical characterization of tape specimens is the initial step of a comprehensive forensic pressure sensitive tape analysis. The construction, composition, and color of tapes vary and, therefore, are useful characteristics for forensic examinations. Visual characteristics and physical measurements are the quickest, most discriminating and least invasive examinations.

6.0 Sample Handling

6.1 An effort should be made not to alter the condition of a questioned specimen before the preliminary examination. In some circumstances, it may be desirable to obtain a sample cutting from the tape before a sample is analyzed for latent fingerprints. Necessary precautions should be taken to eliminate loss or contamination of other types of evidence (e.g., latent prints, DNA, and other trace evidence).

6.2 Samples for testing should not be cut from the ends of the tape if there is a possibility of a physical end match between specimens. A sample should be obtained from an area that does not interfere with the existing end(s), and the location should be marked.

6.3 If tape is received in a tangled condition an attempt should be made to separate it manually with a careful peel. More aggressive techniques such as gentle heat, liquid nitrogen, freezing, or solvents can be used if necessary. However, these techniques could affect the outcome of subsequent analyses and should, therefore, be applied only to the extent necessary.

6.4 All procedures must be conducted in such a manner to ensure that no cross-contamination occurs. The item must be photographed or described prior to conducting any analyses in order to provide documentation of its original condition. Transient evidence (e.g., hair, fiber, paint) should be preserved and documented.

6.5 Tape may not be in its original state due to weathering, stretching, chemicals, etc. These changes may limit the information obtained from the analyses. If the tape does not allow for the full range of examinations, the examinations and analyses that are performed should be reflected in the analyst's notes, and the reasons for the limited examinations should be documented.

7.0 Analysis

Written descriptions, sketches, photography, or other imaging methods must be used to document each sample's characteristics.

A preliminary visual examination of tape construction should include its general appearance, both with the unaided eye and using a stereomicroscope.

For all pressure sensitive tapes, document and record any physical damage (e.g., worn, cut, torn, frayed). The following general visual characteristics should be observed and documented:

- General condition, including any adhering matter
- Tape core markings and packaging information, if available
- Wad, flat pieces, or fragments
- Dimensions (e.g., width and length)
- Number of pieces
- Colors

- Condition of the ends for possible physical matches

7.1 Physical end match
When conducting comparison examinations between two or more tape specimens, the free ends should be carefully examined for possible physical end matches. Even though this type of association is the most compelling type of association, the analyst may elect to continue with a complete analytical analysis of these specimens depending upon the quality of the end match.

7.1.1 General guidelines for physical end match examinations:

- Observe the tear or cut pattern from the backing and adhesive side of both specimens to determine if a physical association is plausible. To observe finer detail, a stereomicroscope should be used to examine the ends.

- If the backing is distorted or folded over and adhered to the adhesive layer, gently straighten it out to restore the torn/cut edge. This may be accomplished with the careful use of forceps, gentle heat, mild solvent, or by freezing.

- Depending on the type of tape, manufacturing marks, creping on a paper backing, printing or any other continuous surface features may be present across fractured edges and would provide additional points of comparison.

- Determine if there are individualizing characteristics (e.g., a flaw or mark) that extends across the fracture. This would be an accidental or anomalous mark that initiates on one piece and terminates across the fracture edge on the other.

- If the tape has a fabric reinforcement layer, solvent (e.g., hexane, chloroform, or xylene) may be used to remove a sufficient amount of adhesive to expose the fabric and ensure alignment of the yarns that have broken across the torn ends.

- Any physical associations must be documented with descriptive notes. Physical associations between specimens that link a suspect to a crime scene or to a victim should be imaged. The imaging method should be dimensionally accurate and include a measuring scale if possible.

- It is strongly recommended that any/all physical end match associations between a questioned specimen and a known specimen be verified by another qualified analyst.

7.2 Physical Features
Tape examinations involve a process of documenting all of the physical characteristics exhibited.

The following characteristics should be documented when applicable:

- Color of adhesive and backing
- Surface texture
- Width measurement
- Overall thickness
- Backing thickness

Each of these characteristics can have a number of sub-elements, all of which can be characterized to complete the examination. Physical characteristics of a tape may change after

removal from the original roll (e.g., weathering, sample handling). The analyst must decide what is an acceptable variation based on the circumstances of the case. Any measuring devices used should be properly checked with applicable quality assurance and control procedures.

7.2.1 Backing
The type of backing must be recorded (e.g., paper, polymer film). The backing should be visually and stereomicroscopically examined for color, texture, and appearance under multiple illumination sources. For comparative examinations, a side-by-side color comparison of two or more backings is appropriate; otherwise, the Munsell or International Commission on Illumination (CIE) color systems may be utilized.

7.2.1.1 Markings on the Backing
Using a stereomicroscope the tape should be examined for features such as calendering marks, striations, dimples, and inclusions. The shapes and type of markings should be documented.

7.2.1.2 Multiple Layer Backings
Tape backings should be examined to determine if multiple layers are present. This can be accomplished by cross-sectioning the tape backing via hand-sectioning or microtoming. One hand-sectioning method is as follows:

- The backing can be removed from the tape adhesive and fabric (though this is not necessary, particularly if the adhesive layer structure is also of interest).
- Two glass slides act as a sample holder by placing the bulk of the tape backing flat between them, with a small portion of the backing remaining outside the edges of the slides.
- The glass slides with the tape backing are attached to a holder (e.g., held with office tape to the side of a 2" pillbox) and positioned under a stereomicroscope such that the slides and backing are perpendicular to the microscope platform.
- Liquid nitrogen or propellant from an aerosol duster is used to freeze that small portion of the backing to make it more rigid for cutting.
- A series of cuts are taken through the edge of the tape backing with a single-edged razor blade positioned nearly parallel to the platform and nearly perpendicular to the backing and slides. The razor blade should also be cooled along with the backing for efficient cutting. Very thin cross-sections are required for proper examination.
- The cross-section(s) are collected and examined with a compound microscope using transmitted light in order to determine layer structure.

The multiple layers should be characterized and then analyzed with appropriate analytical instrumentation.

7.2.2 Adhesive
The adhesive should be visually and stereomicroscopically examined for color and appearance under multiple illumination sources. For comparative examinations, a side-by-side color comparison of two or more adhesives is appropriate; otherwise, the Munsell or CIE color systems may be utilized. Some duct tape adhesives may be multi-layered, and cross-sections of the adhesives should be made when deemed necessary. The layer structure of the adhesive could be evaluated by examination of a cross-section of the ***intact*** tape, prepared using a method like that described in Section 7.2.1.2.

7.2.3 Reinforcement
If reinforcement, such as scrim or filament fibers, is present in a tape, it should be characterized.

7.2.3.1 Duct Tape Reinforcement

The three main features to examine in duct tape reinforcement are weave, yarn description and scrim count.

The weave of the scrim fabric should be assessed using the stereomicroscope. This may require separating the adhesive from the scrim. The most frequently encountered weave patterns are weft-insertion and plain weave. Weft-insertion has chain-stitch warp yarns with texturized filaments in the fill direction. A plain weave has a one over/one under pattern; the warp and fill directions can be a combination of any of the following types of yarns:

- twisted yarns (Z- or S-twist)
- filament fibers bound by another filament fiber
- texturized filament fibers
- straight filament fibers

The fluorescence of the yarns/fibers should be examined using short- and/or long- wavelength illumination.

The scrim count, the warp count per inch and the fill count per inch, should be measured and recorded.

7.2.3.2 Strapping (Filament) Tape Reinforcement
The fibers in filament tape most often consist of synthetic or glass fibers. The fibers are only in the warp direction. The number of bundles across the width of the tape or per unit length should be counted.

The fluorescence of the filament fibers should be examined using short- and/or long- wavelength illumination.

7.2.4 Within-roll variability of physical features
Within-roll variability in some measured physical features is possible, such as tape width, thickness, and scrim count. When variances are observed in the comparison of two tape samples in which all other features are similar, the analyst must decide on an acceptable tolerance. When available, within-roll variances are best derived from a known roll submitted with the case. Alternatively, similar products may be assessed to gain insight into expected variances. Approximate industry tolerances for these features may be found in Mehltretter 2012.

8.0 Report Documentation

The goal is to produce documentation that will be meaningful to a reviewer in the absence of the recording analyst. The resulting notes must be sufficient to support the conclusions reached in the analyst's report. All pertinent data, including any documentation of physical end matches, should be placed into or referenced within the case file. For comparative tape examinations, if significant differences are observed in physical characteristics, no further testing is necessary, and a report can be issued. If no significant differences are observed, instrumental examinations should be performed before a report is issued. Any limitations that affect the conclusions (e.g., sample size, condition of the sample) should be addressed in the report. In sourcing cases, instrumental examinations may be necessary before a report is issued.

9.0 Bibliography

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