JOURNAL OF FORENSIC SCIENCES

J Forensic Sci, May 2011, Vol. 56, No. 3
doi: 10.1111/j.1556-4029.2011.01736.x
Available online at: onlinelibrary.wiley.com

PAPER

CRIMINALISTICS

Maureen J. Bradley,[1] *Ph.D.; Jennifer M. Gauntt,*[2] *M.D.; Andria H. Mehltretter,*[1] *M.S.; Preston C. Lowe,*[1] *M.S.; and Diana M. Wright,*[1] *Ph.D.*

A Validation Study for Vinyl Electrical Tape End Matches*,†

ABSTRACT: Fracture matches are considered the strongest conclusion in the forensic examination of rigid materials, such as glass, metal, and paint. However, publications that support the fracture matching of polymeric films, such as tape backings, are limited. This study was designed to determine the validity and error rate associated with conducting end-match (fracture match) examinations on vinyl electrical tape. Test designs varied the source roll of tape, test preparer, or mode of separation from the roll. Results indicated that each affected the resulting severed tape ends. The analysts examining the end matches also had an effect on the results. Eight end matches in the study were not identified by the initial analysts and were considered inconclusive. One end match was misidentified, resulting in one false positive and an error rate of 0.049%. These results support a comprehensive physical and chemical tape comparison regardless of indications of an end match.

KEYWORDS: forensic science, trace evidence, vinyl electrical tape, end match, error rate, fracture match, physical match, validation study

Poly(vinyl chloride) (PVC) electrical tapes are often submitted to forensic laboratories for comparative examination. The objective of the analysis is to establish a possible evidentiary link between a suspect and a crime or between different crime scenes. Physical attributes and measurements, such as adhesive color, backing surface texture, width, and thickness measurements, can each serve as a parameter that can differentiate samples. Further, the chemical composition of PVC electrical tape samples' adhesives and backings can vary. The variability of PVC electrical tape products has been studied by the forensic community and its evidentiary value has been well established (1–7).

As fracture matches are considered the strongest conclusion in the forensic analysis of rigid materials, such as glass (8–10), metal (8,9,11), and paint (8,9,12,13), a logical first step in tape comparisons is to attempt end matches of tape pieces. In fact, tape end-match examinations have been conducted in forensic laboratories for decades (9,14–16). However, there are only two publications known to the authors (14,17) that validate tape end-match examinations.

[1]Federal Bureau of Investigation, Laboratory Division, 2501 Investigation Parkway, Quantico, VA 22135.
[2]Christiana Care Health System, 4755 Ogletown-Stanton Road, Newark, DE 19718.

*Presented at the 58th Annual Meeting of the American Academy of Forensic Sciences, February 20–25, 2006, in Seattle, WA.

†This is the FBI Laboratory's publication number 06-13. Names of commercial manufacturers are provided for identification only and inclusion does not imply endorsement of the manufacturer, or its products or services, by the Federal Bureau of Investigation. The views expressed are those of the authors and do no necessarily reflect the official policy or position of the FBI or the U.S. Government.

Received 26 Jan. 2010; and in revised form 14 May 2010; accepted 23 May 2010.

The Chemistry Unit of the FBI Laboratory has embarked on a series of studies to address the validity of conducting end matches on different types of tapes submitted as evidence to forensic laboratories. The first phase addressed conducting end matches on duct tape (17). This phase was designed to determine the validity of conducting end matches on vinyl electrical tapes and to evaluate the error rate associated with these examinations. These studies can be utilized to address admissibility challenges, such as *Frye* (18) and *Daubert* (19).

Materials and Methods

Seven rolls of vinyl electrical tape were used in this study. All were commercially available at common retail stores, black in color, and nominally ¾ inch wide. The rolls represented various product grades and manufacturers (Table 1).

Vinyl electrical tape can be removed from a roll through a variety of means (e.g., cutting, hand tearing, and dispenser tearing). The FBI Laboratory does not conduct end matches on cut pieces of vinyl electrical tape because of insufficient features to compare between the two severed ends. Furthermore, because of its plasticity, some vinyl electrical tapes will not tear, but rather stretch and deform until they snap apart. This mode of separation from the roll was not evaluated in this study because the resulting ends are generally too deformed and distorted to attempt an end-match examination. Discussions occurred between the authors and FBI Laboratory Explosives Unit personnel (who frequently handle electrical tape in relation to improvised explosive device [IED] assembly) to determine how vinyl electrical tape might be separated from a roll when the tape could not be torn. The user could resort to cutting the tape, or alternatively, placing a nick on the side of the tape with a knife or other sharp implement and then tearing it the rest of the way. Therefore, the modes of separation utilized in this study

2011 American Academy of Forensic Sciences
Published 2011. This article is a U.S. Government work and is in the public domain in the U.S.A.

were torn by hand, nicked and then torn by hand, and torn using the dispenser provided with the roll.

As an additional variable, the sample sets were prepared by two members of the FBI Laboratory's Explosives Unit designated as preparers A and B. These individuals were selected to prepare the sample sets because they routinely assemble IEDs for training purposes and they do not conduct tape end-match examinations.

Test Set Designs

Ten tests were designed in which the roll of tape, the test preparer, and the mode of separation from the roll were varied (Table 2). The test designs were designated as 1 through 10. An attempt was made to have a comparable number of test sets with either hand-torn or nicked and then hand-torn ends. For test designs 1 and 4, the preparer was instructed to first try to tear the tape; if unsuccessful, the method of nicking and then tearing the tape was employed. For both of these test designs, the tapes would not tear without being stretched and deformed; so, the preparer resorted to nicking and then tearing the tapes.

Preparation of Test Sets

Three sets of each of the 10 test designs were prepared. The three sets within each test design were designated A, B, and C. Preparation of each of the resulting 30 test sets was as follows: 10 strips of tape were separated from the master roll as prescribed in the test design and adhered sequentially to a plastic substrate. Sequential numbers 1–10 were marked on the plastic substrate adjacent to the individual strips. Each strip of tape was then arbitrarily labeled with the letters A through J. Each test set was digitally photographed to document the original, sequential order of the tape strips. The order within each test set was verified by a second person. The plastic substrate to which the strips of tape were adhered was then cut to separate the tape strips from one another. It was cut in a manner so that end matching of the substrate was not possible. For each test set, three or four strips were removed at random. The six or seven remaining strips were also labeled with their letter designations upside down so that the strips' correct orientation was not apparent. The six or seven strips were then administered as one test set.

Depending on whether six or seven strips remained of the original 10, the number of end matches per test set could vary from one to six. Each of the three analysts received 10 test sets, one of each test design. The three test sets (A, B, and C) of each design were distributed to the analysts. The test participants were instructed to evaluate whether end matches existed among the strips of tape in each set. With the aid of a stereo microscope (6–50×), end matches between two severed pieces of tape were evaluated by removing the pieces from their plastic substrate, aligning the fractured edges, and observing the tear pattern from both the backing and adhesive sides.

TABLE 1—*Vinyl electrical tape products.*

Source	Price	Purchased at*
Duck™ brand, 7 mil	$0.47	Lowe's
Frost King®, 7 mil	$0.59	The Home Depot
Ace brand, 7.0 mil	$0.79	Ace Hardware
Ace brand, 7.5 mil, premium grade	$1.29	Ace Hardware
3M Tartan™ 1710, 7 mil	$0.47	The Home Depot
Scotch® Super 33+, 7 mil	$2.68	The Home Depot
Scotch® Super 88, 8.5 mil, professional grade	$3.77	The Home Depot

*Lowe's, Stafford, VA; The Home Depot, Stafford, VA; Ace Hardware, Woodbridge, VA.

TABLE 2—*Test set designs.*

Test Design	Source Roll	Preparer	Mode of Separation
1	Duck™ brand, 7 mil	A	Nick and then tear
2	Frost King®, 7 mil	A	Tear
3	Frost King®, 7 mil	B	Tear
4	Ace brand, 7.0 mil	A	Nick and then tear
5	Ace brand, 7.5 mil	A	Nick and then tear
6	Ace brand, 7.5 mil	B	Nick and then tear
7	3M Tartan™ 1710, 7 mil	A	Nick and then tear
8	3M Tartan™ 1710, 7 mil	B	Nick and then tear
9	Scotch® Super 33+, 7 mil	B	Dispenser provided
10	Scotch® Super 88, 8.5 mil	B	Nick and then tear

Results

A total of 106 end matches existed in the 30 test sets that were administered. Ninety-eight of the 106 end matches were identified. The remaining eight end matches were not identified, and one misidentification was reported. For this study, "not identified" is considered inconclusive, in that the analyst did not note sufficient correspondence between the ends to identify an end match; "misidentified" is considered incorrect (false positive). Figures 1–6 are documentation of various end matches correctly identified in this study. These photographs demonstrate the varying degrees of characteristic features that can be observed in vinyl electrical tape ends. Figure 7 is one of the eight end matches that was not identified. Figure 8 is a photograph of the two pieces that were incorrectly identified as an end match. The results of the initial administration of the test sets are summarized below and in Table 3.

Test Design 1: 8 of the 8 existing end matches were identified.

Test Design 2: 11 of the 12 existing end matches were identified. One from test set 2B was not.

Test Design 3: 10 of the 10 existing end matches were identified.

Test Design 4: 10 of the 10 existing end matches were identified.

Test Design 5: 7 of the 8 existing end matches were identified. One from test set 5B was not.

Test Design 6: 8 of the 12 existing end matches were identified. Three of those not identified were from test set 6A and one was from test set 6B.

Test Design 7: 12 of the 12 existing end matches were identified.

Test Design 8: 11 of the 12 existing end matches were identified. One from test set 8C was not. One tape pair from test set 8B was incorrectly identified as having an end match.

Test Design 9: 10 of the 10 existing end matches were identified.

Test Design 10: 11 of the 12 existing end matches were identified. One from test set 10C was not.

In test sets where an end match was not identified or incorrectly identified by the original analyst, the entire test set was re-evaluated independently by the two remaining analysts and each rendered his or her opinion. The analysts who were re-evaluating the test sets were not provided with any information regarding the results of the initial administration of the test sets. The results of these re-evaluations are summarized below and in Table 4. Included in these results is the identity of the tape pairs that were unidentified or misidentified in the original administration, as well as in the re-evaluation, of the test sets.

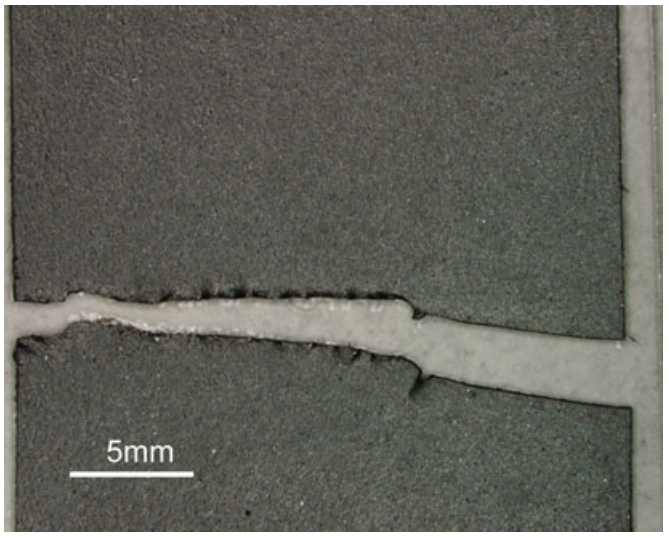

FIG. 1—*Test set 4A, Ace brand, 7.0 mil vinyl electrical tape nicked and then hand-torn by preparer A.*

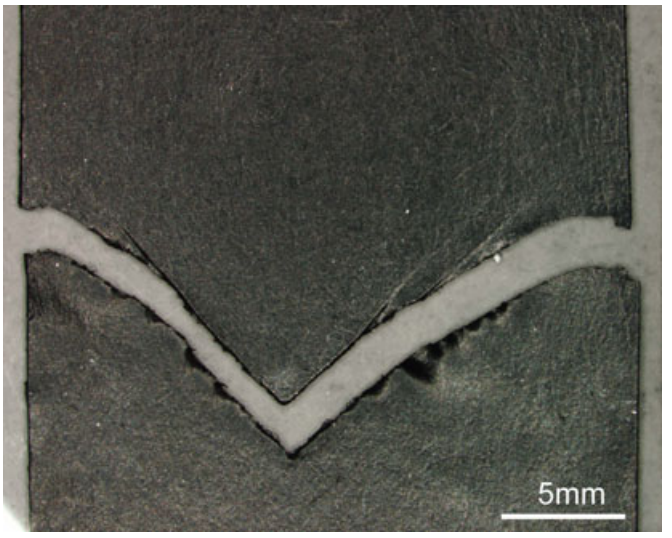

FIG. 3—*Test set 9A, Scotch® Super 33+, 7 mil vinyl electrical tape. Preparer B utilized the dispenser provided.*

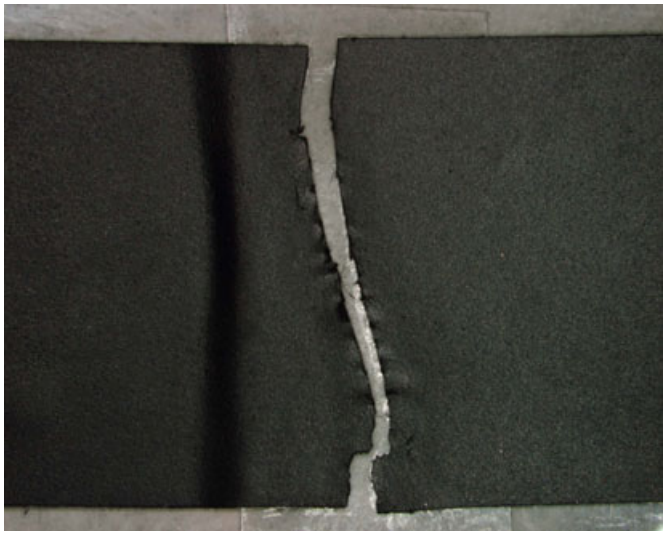

FIG. 2—*Test set 5A, Ace brand, 7.5 mil vinyl electrical tape nicked and then hand-torn by preparer A.*

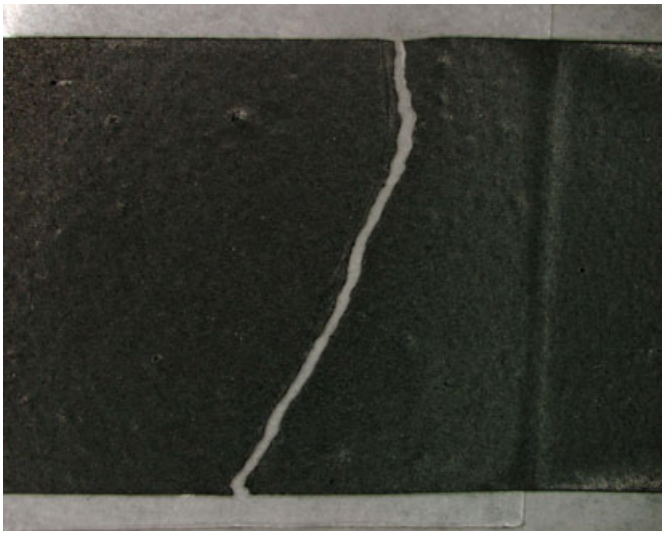

FIG. 4—*Test set 3C, Frost King® brand, 7 mil vinyl electrical tape hand-torn by preparer B.*

Test Set 2B: One end match, E-G, was not identified in the original administration of the test set.

Re-evaluation results of test set 2B: The two analysts re-evaluating this test set correctly identified all of the end matches within this set.

Test Set 5B: One end match, I-J, was not identified in the original administration of the test set.

Re-evaluation results of test set 5B: One of the two analysts re-evaluating this test set correctly identified the previously unidentified end match; the other did not. The remaining end matches were correctly identified.

Test Set 6A: Three end matches, B-G, F-H, and C-D, were not identified in the original administration of the test set.

Re-evaluation results of test set 6A: The two analysts re-evaluating this test set correctly identified the three previously unidentified end matches. However, one analyst did not identify the end match, F-J, identified by the original analyst; the other analyst did.

Test Set 6B: One end match, E-G, was not identified in the original administration of the test set.

Re-evaluation results of test set 6B: One of the two analysts re-evaluating this test set correctly identified the previously unidentified end match; the other did not. Further, the latter analyst did not identify an end match, H-F, previously identified by the original analyst. The remaining end matches were correctly identified.

Test Set 8B: One tape pair, H-I, was incorrectly identified as an end match in the original administration of the test set.

Re-evaluation results of test set 8B: One of the two analysts re-evaluating this test set also incorrectly identified an end match between the same two pieces, H-I; the other did not. Further, both analysts re-evaluating this test set did not identify an end match, D-E, previously identified by the original analyst. The remaining end matches were correctly identified.

Test Set 8C: One end match, H-J, was not identified in the original administration of the test set.

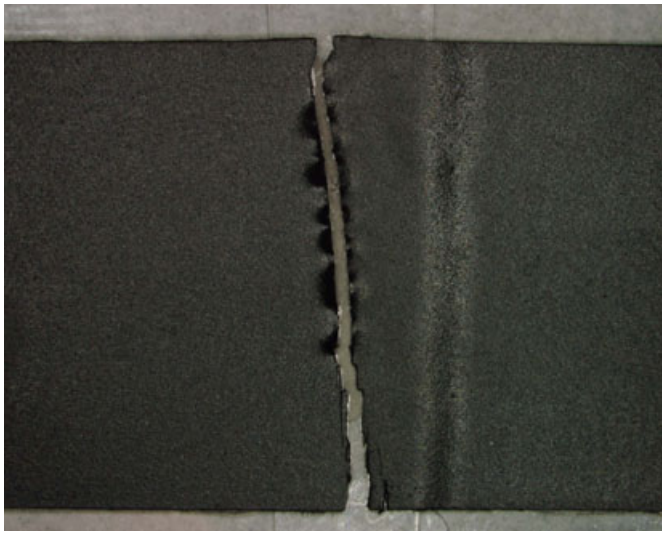

FIG. 5—*Test set 6C, Ace brand, 7.5 mil vinyl electrical tape nicked and then hand-torn by preparer B.*

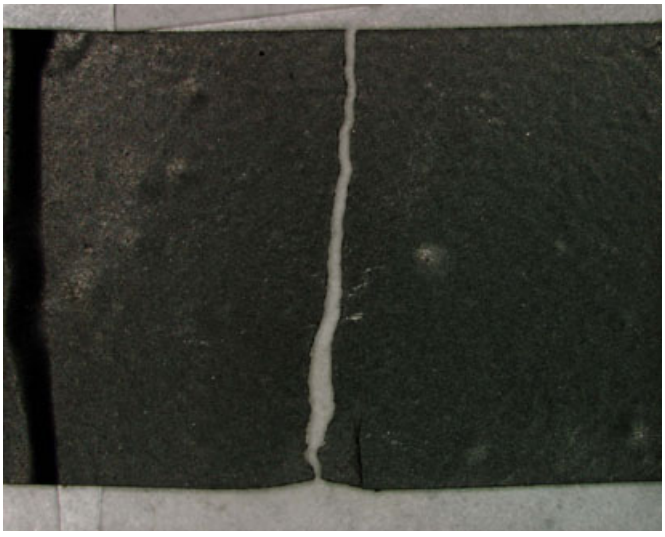

FIG. 7—*Test set 2B, Frost King® brand, 7 mil vinyl electrical tape hand torn by preparer A. This end match was not identified in the initial administration of the test sets.*

FIG. 6—*Test set 8C, 3M Tartan™ 1710, 7 mil vinyl electrical tape nicked and then hand-torn by preparer B.*

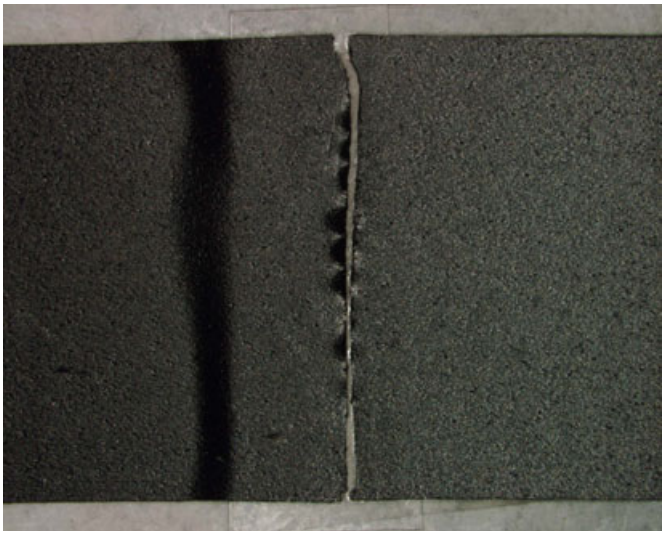

FIG. 8—*Test set 8B, 3M Tartan™ 1710, 7 mil vinyl electrical tape nicked and then hand-torn by preparer B. Although "identified" as an end match during this study, these two pieces of tape were not torn from each other. Therefore, this association was incorrectly identified as an end match.*

Re-evaluation results of test set 8C: One of the two analysts re-evaluating this test set identified the previously unidentified end match; the other did not. The remaining end matches were correctly identified.

Test Set 10C: One end match, B-E, was not identified in the original administration of the test set.

Re-evaluation results of test set 10C: One of the two analysts re-evaluating this test set identified the previously unidentified end match; the other did not. The remaining end matches were correctly identified.

This study was designed to assess both the validity of conducting end-match examinations on vinyl electrical tape and the error rate associated with such examinations. Two thousand one hundred and forty-two possible end matches, including 106 actual end matches, existed in the 30 test sets that were administered. Based on the initial examination of the test sets, 98 of the 106 end matches were correctly identified and one error (misidentification) was reported.

The misidentification error is considered to be a false-positive result. The error rate for this study was calculated as follows:

$$\frac{1 \text{ error}}{2142 \text{ possible} - 106 \text{ actual}} \times 100\% = 0.049\%$$

To arrive at the value of 2142 for the total number of possible end matches, the number of possible end matches in each test set was calculated and the values from all the test sets were summed. For example, test set 1A included six pieces of tape. Each end on piece 1 could be compared to each end of pieces 2 through 6, resulting in 20 comparisons. Each end of piece 2 could then be compared to each end of pieces 3 through 6 (piece 2 was already compared to piece 1 above) to give 16 comparisons. Likewise,

TABLE 3—*Results of the initial administration of each test design reported as # identified/# present. The identity of the test sets with an unidentified or misidentified* end match are indicated below the results.*

Test Design	1	2	3	4	5	6	7	8	9	10
Analyst										
1	2/2	3/4 Set 2B	3/3	4/4	3/3	1/4 Set 6A	3/3	3/4 Set 8C	4/4	2/3 Set 10C
2	3/3	4/4	4/4	3/3	2/3 Set 5B	4/5 Set 6B	5/5	4/4	3/3	4/4
3	3/3	4/4	3/3	3/3	2/2	3/3	4/4	4/4, +1* Set 8B	3/3	5/5

TABLE 4—*Results of the initial administration (in bold) and subsequent re-evaluation for those test sets that initially had an unidentified or misidentified* end match. Reported as # identified/# present, with (+1) indicating the misidentification.*

Test Set	2B	5B	6A	6B	8B	8C	10C
Analyst							
1	**3/4** **E-G**	2/3 **I-J**	**1/4** **B-G, F-H, C-D**	3/5 E-G, H-F	3/4 D-E	**3/4** **H-J**	**2/3** **B-E**
2	4/4 –	**2/3** **I-J**	3/4 F-J	**4/5** **E-G**	3/4, (+1) D-E, H-I*	3/4 H-J	2/3 B-E
3	4/4 –	3/3 –	4/4 –	5/5 –	4/4, (**+1**) **H-I***	4/4 –	3/3 –

each end of piece 3 could be compared to each end of pieces 4 through 6 (12 comparisons), each end of piece 4 to each end of pieces 5 through 6 (eight comparisons), and finally, each end of piece 5 to each end of piece 6 (four comparisons). Summing all of these together would yield 20 + 16 + 12 + 8 + 4 = 60 comparisons for this test set. This series of comparisons can be described mathematically by the formula:

$$\text{number of comparisons per test set} = n(n-2)/2$$

where n = the number of ends.

It should further be noted that all ends were compared to all other ends regardless of whether an end match was already suspected between two pieces. For test set 9, the calculation was reduced by half, because the linear orientation was apparent based on the dispenser-cut ends (see Fig. 3).

The eight end matches that were not identified in the initial administration are considered inconclusive, because the original analyst did not feel enough features were present to report an end match. One of the analysts specifically commented in their notes when an end match was suspected but not reported because of insufficient features for comparison or distortion of the ends. The same analyst was responsible for six of the eight unidentified end matches.

Because not all of the test sets were re-examined, an error rate was not calculated from the re-evaluation phase data.

Discussion

Three parameters were varied in this study to determine whether they affect the ability to conduct end match examinations on vinyl electrical tape: the person who prepared the test set, the source roll of tape, and the mode of separation from the roll.

In preparing the test sets for the study, two people (preparers A and B) separated the tape strips from the source rolls as prescribed. They were each responsible for preparing the same number of test sets. Upon evaluation of the eight unidentified and one incorrectly identified end match, it was found that preparer B prepared six of the eight end matches that were not identified, as well as the incorrectly identified end match. The remaining two end matches that were not identified were prepared by preparer A.

Evaluation of the results demonstrated that five of the eight unidentified end matches originated from the same roll of tape (test designs 5 and 6). This roll of tape was a premium grade tape manufactured under Ace Hardware's store brand. Although more expensive than some of the other tapes used in the study, it was not the most expensive, nor was it the highest grade of tape used in the study. There was no obvious explanation as to why this source roll of tape would lead to such a disproportionate number of unidentified end matches.

The three modes of separation of tape from the roll evaluated in this study included hand tearing, nicking with a sharp implement and then hand tearing, and using the dispenser provided with the roll. Twenty-two of the 106 end matches that existed in the study were created by hand tearing from the source roll. One of the hand-torn end matches was not identified. Seventy-four of the 106 end matches that existed in the study were created by nicking and then tearing the tape. Seven of the 74 nicked and then torn end matches were not identified. Furthermore, the misidentified end match was produced by nicking and then tearing the tape. Ten of the 106 end matches that existed in the study were created from the dispenser provided with one of the source rolls; all 10 of the end matches were identified. The authors recognize that there are a disproportionate number of nicked and torn ends when compared to the other two methods of separating the tape. Therefore, no conclusion can be drawn regarding the affect of the mode of separation on end match accuracy in this study.

The majority of the unidentified end matches (six of eight), as well as the misidentified end match, resulted from preparer B nicking and tearing the tape. Further, four of these unidentified end matches resulted from the same roll of tape (test design 6). The same roll of tape and mode of separation were also used in test design 5 which was prepared by preparer A. Only one of the eight end matches was not identified in the test sets from design 5. These results would tend to support an argument that the preparer has a larger effect than the source roll on the ability to identify an end match. However, the variables are not necessarily independent of one another. For example, the source roll has an effect on the mode in which the tape can be separated into pieces; some tapes tear and others do not, independent of the person who is attempting to separate the tape. Regardless of the weight of the variable, each of those being evaluated in this study (the person who separated the tape, the source roll of tape, and the mode utilized to separate the tape), independent, or in combination with one another, have an effect on the characteristic features created in the tape ends. These characteristic features, in turn, could have an effect on the ability to identify an end match of vinyl electrical tapes.

Although not an intended variable in the study, the analyst conducting the end matches must also be considered in these results.

As stated previously, six of the eight unidentified end matches in the initial administration were attributed to analyst 1. This person appears to have taken a more conservative approach than the others. This is further supported in the three test sets that this analyst re-evaluated which resulted in four unidentified end matches. These numbers are higher in comparison with the other analysts in the study. Analyst 3, for example, correctly identified all end matches both within the original test sets and the ones assigned for re-evaluation; however, that analyst also initially reported the misidentification. One may attempt to correlate these results to the experience level of the analyst because some, particularly newer ones, may be overly conservative or overly confident relative to more experienced analysts. However, because both analysts 1 and 3 had roughly the same amount of experience, 6.25 and 5.75 years, respectively, and analyst 2 had 3.5 years of experience, the results of this study do not support that supposition.

Traditionally, forensic tape examinations are considered complete in any tape case where an end match of value (e.g., linking suspect to victim or crime scene, or two crime scenes together) is observed and confirmed by a second qualified individual. Recognizing the inherent difficulty in accurately determining end matches on an amorphous polymer, such as tape, the FBI Laboratory modified its tape comparison protocol in 2003. The revision mandated that for all cases where there was an end match of value, after the end match was confirmed by a second qualified individual, the full complement of examinations (physical and chemical analyses) would also be conducted on the reconstructed tape specimens.

The rationale for the protocol revision was twofold. First, unlike solid, rigid materials, tape ends can be permanently deformed or distorted when they are severed. Therefore, it may be possible to associate tape ends that do not actually match. This study has demonstrated that this can in fact occur. In test set 8B, one pair of tape ends were incorrectly identified as an end match by the initial analyst. The same error was repeated by a second analyst, independent of the first, in the re-evaluation phase of the study. Therefore, regardless of whether an end match is confirmed by a second individual or not, an error may still be reported. The second reason for modification of the protocol is the possibility that a conclusion based solely on a tape end match may not be admitted into court. At the time the protocol was modified, no published studies existed that directly addressed the validity of conducting tape end matches or the error associated with them. Without these studies, the admissibility of tape end-match results could be questioned. The revision to the FBI Laboratory's tape comparison protocol addressed both of these issues. As a result, the additional examinations allow the tapes to be associated to one another based on comparison of their physical characteristics and chemical composition of each of their components. The distinct features of the torn edges of the tapes are then addressed to support the conclusion of an end match.

Acknowledgments

The authors thank Angela Pendry and Julia Joyce, previously of the FBI Laboratory's Explosives Unit, for their assistance in the preparation of this study.

References

1. Smith JM. Forensic examination of pressure sensitive tape. In: Blackledge RD, editor. Forensic analysis on the cutting edge. Hoboken, NJ: Wiley Interscience, 2007;291–332.
2. Kee TG. The characterization of PVC adhesive tape. Proceedings of the International Symposium on the Analysis and Identification of Polymers; 1984 Jul 31–Aug 2; Quantico, VA. Washington, DC: U.S. Department of Justice, Federal Bureau of Investigation, 1984;77–85.
3. Keto RO. Forensic characterization of black polyvinyl chloride electrical tape. Crime Lab Digest 1984;11:71–4.
4. Williams ER, Munson TO. The comparison of black polyvinylchloride (PVC) tapes by pyrolysis gas chromatography. J Forensic Sci 1988;33:1163–70.
5. 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.
6. Goodpaster JV, Sturdevant AB, Andrews KL, Briley EM, Brun-Conti L. Identification and comparison of electrical tapes using instrumental and statistical techniques: II. Organic composition of the tape backing and adhesive. J Forensic Sci 2009;54:328–38.
7. Mehltretter AH, Bradley MA, Wright DM. Analysis and discrimination of electrical tapes: Part I. Adhesives. J Forensic Sci 2011;56(1): 82–94.
8. Kirk PK. Crime investigation: physical evidence in the police laboratory. New York, NY: Interscience, 1953.
9. Osterburg JW. The crime laboratory: case studies of scientific criminal investigation. Bloomington, IN: Indiana University Press, 1967.
10. Thornton JI. Interpretation of physical aspects of glass evidence. In: Caddy B, editor. Forensic examination of glass and paint. New York, NY: Taylor and Francis, 2001;97–121.
11. Orench J. A validation study of fracture matching metal specimens failed in tension. AFTE J 2005;37:142–9.
12. VanHoven HA, Fraysier HD. The matching of automotive paint chips by surface striation alignment. J Forensic Sci 1983;28:463–7.
13. ASTM International. E 1610-02(2008) Standard guide for forensic paint analysis and comparison. West Conshohocken, PA: ASTM International, 2008.
14. Agron N, Schecter B. Physical comparisons and some characteristics of electrical tape. AFTE J 1986;18:53–9.
15. Blackledge RD. Tapes with adhesive backings: their characterization in the forensic science laboratory. In: Mitchell J, editor. Applied polymer analysis and characterization: recent developments in techniques, instrumentation, problem solving. Munich, Germany: Hanser, 1987; 413–21.
16. Courtney M. Evidential examinations of duct tape. J Southwest Assoc Forensic Sci 1994;16:10–6.
17. Bradley MJ, Keagy RL, Lowe PC, Rickenbach MP, Wright DM, LeBeau MA. A validation study for duct tape end matches. J Forensic Sci 2006;51:504–8.
18. *Frye v. United States*, 293 F.1013, 1014 (D.C. Cir. 1923).
19. *Daubert v. Merrell Dow Pharmaceuticals, Inc.*, 509 U.S. 579 (1993).

Additional information and reprint requests:
Maureen J. Bradley, Ph.D.
Forensic Examiner/Chemist
Federal Bureau of Investigation, Laboratory Division
2501 Investigation Parkway, Room 4220
Quantico, VA 22135
E-mail: maureen.bradley@ic.fbi.gov