J Forensic Sci, July 2006, Vol. 51, No. 4
doi:10.1111/j.1556-4029.2006.00173.x
Available online at: www.blackwell-synergy.com

TECHNICAL NOTE

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Evaluation and Comparison of the Electrostatic Dust Print Lifter and the Electrostatic Detection Apparatus² on the Development of Footwear Impressions on Paper*

ABSTRACT: The Electrostatic Dust Print Lifter (EDPL) and the Electrostatic Detection Apparatus² (ESDA²) were compared to determine if both processes could be used to develop footwear impressions of the same or similar quality and in what order they should be used to develop the highest quality footwear impression. The sensitivity of each technique was also evaluated. The quality of the footwear impressions developed was determined by comparing 25 individual characteristics present on the known shoe to the footwear impressions developed using each technique. The footwear impressions were made by stepping on paper placed over several different surfaces, which included: linoleum, industrial Berber carpet, nylon carpet placed over a $\frac{3}{8}$-in. pad, ceramic tile, cardboard, 1-in. foam, 4-in. foam, cement, asphalt, grass, and mulch. Each of the papers placed on these surfaces was developed using the EDPL before the ESDA² and vice versa. The sensitivity test for the ESDA² was conducted by processing 10 sheets of stacked paper that were stepped on with the known shoe, beginning with the top sheet. The sensitivity test for the EDPL was conducted by processing 10 sheets of paper stepped on with the known shoe in succession. This study determined the footwear impressions developed using the EDPL were of better comparative value than impressions developed with the ESDA². On average, 72.4% of the individual characteristics from the known impression were identified on images developed when the EDPL was used first compared with an average of 38.9% when the ESDA² was used first. Therefore, if only one technique is used, the EDPL should be chosen. The sensitivity test determined the ESDA² develops high-quality footwear impressions on only the top sheet of paper. No footwear impressions were developed on any sheets under the top sheet of paper. The sensitivity test also determined the EDPL results increase in quality as the amount of dust residue decreases on the surface.

KEYWORDS: forensic science, footwear impression, shoe impression, individual characteristics, dust print, indented, Electrostatic Detection Apparatus², Electrostatic Dust Print Lifter

Footwear impression evidence is commonly found at many crime scenes. Individuals committing crimes may leave footwear impressions as they enter, walk around, and exit the crime scene. Footwear impression evidence is usually found on ground surfaces, but may also be located on other items, including paper. Stepping on a sheet of paper may result in a positive, dry residue impression, due to the deposition of dry dust and other particles onto the paper by the sole of the shoe. During the formation of the impression, an electrostatic charge may be created on the surface of the paper, which assists dust and other trace particles or residues to adhere to the surface (1). At the same time, depending on the type of surface the paper is located on, an indentation may be formed in the paper by the shoe.

William J. Bodziak defines impression evidence as "objects or materials that have retained the characteristics of other objects or materials through direct physical contact" (1). Unlike shoe impressions left in blood or other visible materials, dust impressions are often latent and difficult to locate at a crime scene. Some dust impressions can be found using oblique lighting; however, the contrast on paper may be so low that the impression is still not visible. In the past, several chemical methods have been used to detect and develop latent impressions on paper, including processing with ninhydrin and physical developer. Ninhydrin has been shown to react with the amino acids found on shoes from contact with substances containing amino acids. When dust is present, suspected impressions may be lifted from paper using the Electrostatic Dust Print Lifter (EDPL), which would then allow the impression to be visualized and enhanced.

Electrostatic lifting was first developed by Tokyo police sergeant Sancyasu Toma and three other identification experts in 1965 (1). Their method utilized static electricity to lift footwear impressions (1). In 1970, Kato Masao, a police officer in Shikoku, Japan, created the first electrostatic lifting device. The device consisted of an electrode plate, a black vinyl sheet, and a static electricity machine that could produce 14,000 V. One disadvantage of this device was that it used a permanent lifting plate, which meant each impression would have to be photographed or transferred before another impression could be developed (1). In 1983, Brennan et al. created the first battery operated electrostatic lifters

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*Presented as a poster at the 57th Annual Meeting of the American Academy of Forensic Sciences in 2005.

Received 23 July 2005; and in revised form 1 Oct. 2005, 20 Dec. 2005; accepted 2 Jan. 2006; published 21 June 2006.

(1). Finally, Foster & Freeman Ltd. developed the first portable electrostatic lifter that operated on batteries and used separate pieces of lifting film (1).

Another electrostatic device that can be used to recover impressions from paper is the Electrostatic Detection Apparatus^2, also known as ESDA^2. D. J. Foster and D. J. Morantz invented the ESDA^2 in 1978 at the London College of Printing (2). Traditionally, the Electrostatic Detection Apparatus has been used to develop indented writing on paper. As a sheet of paper is stepped on, the shoe will leave an impression on the paper in the form of an indentation, which can be processed like indented writing. However, the film can also be charged in the same way as the electrostatic dust print lifter to detect dust left by a footwear impression on paper. In this case, the ESDA^2 is used to lift the dust by charging the imaging film placed over the impression. The imaging film can then be separated from the paper and placed over a dark background to visualize the dust impression (3). Therefore, the ESDA^2 may be used to develop shoe impressions on paper by either lifting the dust print deposited on the paper or by detecting the changes that occur physically within or upon the indented paper.

Theoretically, the primary function of the EDPL is to remove a dust impression from a surface without altering its physical properties. As the paper should not be altered when the dust is removed, the ESDA^2 should still be able to detect microscopic or macroscopic changes in the paper created from the shoe impression. At the same time, the ESDA^2 is a nondestructive instrument, and the imaging film protects the paper. Therefore, it should be possible to develop the indented impression on the paper using the ESDA^2 and then remove the dust impression with the EDPL. The quality of the indentation will be influenced by the substrate the paper is on when the footwear impression is made. Therefore, softer surfaces should result in better impressions due to the resulting indention and increased contact of the shoe outsole to the paper. This study was conducted to determine which process, the ESDA^2 or the EDPL, is better for recovering shoe impressions on paper and what order the two techniques should be used if they are both used.

Methods

Each sample impression was made by a size 9 $\frac{1}{2}$ Cherokee men's boot (right). At the start of the research, a known impression of the shoe was made using black powder and a gelatin lifter. Twenty-five specific individual characteristics were identified in the impression and noted for comparison (Fig. 1). Once the impression was made, the shoe was cleaned with tap water and was not worn again until the collection of each sample.

The sample collection process was identical for each sample collected. A blank sheet of paper was stepped on at the start of each collection period, in order to remove excess dust that may have collected on the shoe over time. Ten paces of the right shoe were performed down a carpeted hallway and the eleventh step was placed on a sheet of 8 $\frac{1}{2} \times$ 14-in. legal sized regular copy paper, taken from the center of the package and placed on top of each sample surface. The sample surfaces included: linoleum, industrial Berber carpet, nylon carpet placed over a $\frac{3}{8}$-in. pad, ceramic tile, cardboard, 1-inch foam, 4-inch foam, cement, asphalt, grass, and mulch. The procedure was performed twice for each sample surface to accommodate two types of developmental procedures; the EDPL was performed first and the ESDA^2 was performed second on the same sample, and vice versa. These two combinations of development techniques were used to compare the use of one technique to the other and the quality of the impression developed.

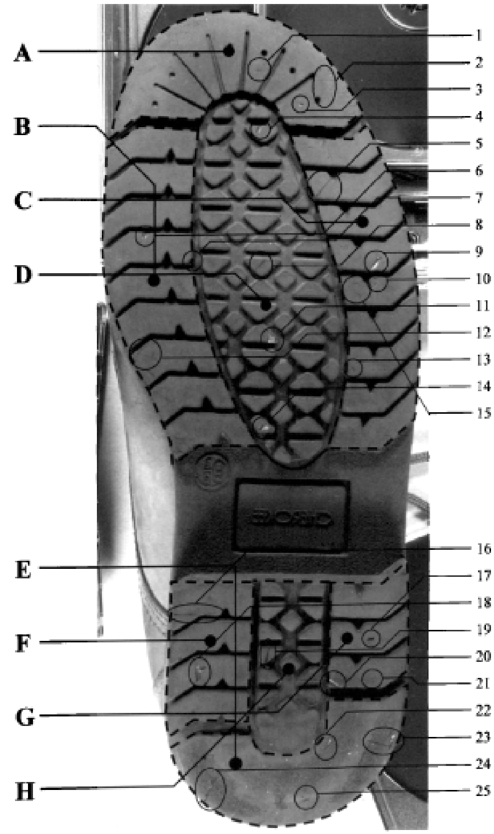

FIG. 1—*Known Cherokee men's shoe outsole size 9 $\frac{1}{2}$ in. The shoe outsole has been labeled with the 25 individual characteristics and divided into eight sections. Note: the image is reversed.*

The collection of samples on surfaces located outdoors (cement, asphalt, grass, and mulch) was conducted in the same manner as the indoor sample surfaces. Before making the impression on the paper, 10 paces were performed on the same hallway carpet. The shoe was then removed and transported outdoors to the surface. The shoe was put back on and the eleventh step was made with the paper placed on the underlying surface.

Development of the latent footwear impressions using electrostatic lifting techniques utilized the ESP900 Electrostatic Dust Print Lifter (Sirchie® Fingerprint Laboratories, Youngsville, NC) and followed the basic electrostatic lifting procedure. The electrostatic dust print lifter functions by using a high voltage source to impose a static charge to a Mylar film. The paper that yields the shoe impression is placed under the Mylar film. The high voltage source is placed in contact with a grounding plate and the metallic side of the Mylar film. Static electricity created by the source causes the dust or residue particles from the footwear impression to be deposited on the black side of the Mylar film. Any air bubbles present between the impression and the Mylar film when the voltage is applied are rolled out with a roller. The resulting deposited impression on the Mylar film is a mirror image of the impression originally on the paper. The black surface of the Mylar film provides enough contrast for the dust impression to be photographed using oblique lighting in a dark room (1). The resulting impression can be compared directly with footwear suspected to have deposited the print (4). Immediately after lifting, each footwear impression was photographed with a Nikon D1X digital camera (Nikon, Melville, NY) (5.3 effective megapixel CCD) as a

Tiff image, then compared with the known shoe from the photograph, and stored in a manila folder.

The development of the footwear impressions using the Electrostatic Detection Apparatus^2 (Foster & Freeman Ltd., Sterling, VA) was consistent with the cascade development procedure described in the ESDA^2 manual (5). The document containing the suspected impression was placed on a stainless steel porous platen and covered with imaging film. The document and imaging film was held in place by a vacuum beneath the platen and subjected to a high voltage static charge with a corona wand. When developing impressions created by indentations in the paper, the static charge accumulates in the areas of the impressions where the paper fibers have been microscopically or macroscopically altered. The metal platen is then lifted on one side and the cascade developer, consisting of silicon beads covered in black toner, is poured over the imaging film. In order to be consistent in the development of each sample, one full bottle of cascade developer was used to develop each ESDA^2 image. After applying the cascade developer over the imaging film, the toner will be attracted to areas of higher static charge and will deposit in the areas where indentations or changes are present. The resulting impression will appear black where the indentations occur (6). The impressions developed were preserved by placing an adhesive clear plastic sheet over the imaging film (6). The ESDA^2 lifts were then compared directly to the known shoe, and then photographed with the Nikon D1X digital camera.

Sensitivity testing was performed for each development technique. For the ESDA^2, 10 sheets of stacked paper were placed on the carpeted hallway floor. Ten paces were taken with the known shoe and the 11th step was placed on top of the 10 sheets. Each sheet was processed with the ESDA^2 until the impression was no longer visible. For the EDPL, 10 sheets were placed consecutively down the same hallway and each sheet was stepped on in order, beginning with the eleventh step on the first sheet, 12th step on the second sheet, etc. Again, each sheet was processed with the EDPL until the impression was no longer visible or the 10th sheet was reached.

Results

A total of 44 separate footwear impressions were obtained using two developmental procedures. For each surface used, two samples were made and four footwear impressions were developed. The first of the two samples for each surface was developed using the EDPL first and the ESDA^2 second. The second of the two samples for each surface was developed using the ESDA^2 first and the EDPL second. The impressions developed on each sample were compared with 25 individual characteristics present on the known shoe (Fig. 1).

Generally, sample impressions developed using the ESDA^2 first were entirely visible (Table 1). The quality of the images allowed comparison with shoe size, design, and wear characteristics, but did not provide sufficient detail for identification of all 25 individual characteristics. Softer surfaces such as the carpet and foam samples yielded better impressions than harder surfaces. The highest number of individual characteristics identified using the ESDA^2 first and the EDPL second were present on the footwear

TABLE 1—*Individual characteristics identified with the ESDA^2-EDPL method.*

Individual Characteristic	Linoleum		Industrial Carpet		Nylon Carpet		Ceramic Tile		Cardboard		1-in. Foam		4-in. Foam		Cement		Asphalt		Grass		Mulch	
1																						
2																						
3				•																	○	
4		•	○	•	○	•		•		•			○		○			•			○	•
5			○			•			○	•	○		○						○			
6			○	•	○	•	○	•	○	•	○				○		○		○	•		
7		•	○	•	○	•	○	•	○	•	○	•			○	•	○	•	○	•	○	•
8	○		○						○	•	○	•					○	•	○	•	○	
9		•	○		○				○		○		○		○		○					
10		•	○	•	○	•		•	○	•	○	•	○		○		○	•	○	•		
11	○	•	○	•	○	•		•	○	•	○	•	○	•	○	•	○	•	○	•	○	•
12			○																			
13																						
14					○																	
15								•	○				○		○							
16	○	•	○		○		○	•	○	•	○		○		○				○	•		
17			○																			
18			○		○			•							○		○	•				
19	○	•	○		○	•			○	•					○		○	•	○	•		
20			○		○	•	○	•	○	•			○		○		○	•	○		○	
21																	○					
22			○		○					•							○	•	○			•
23								•							○				○			
24			○		○	•		•	○	•							○		○			
25								•														
Sections of impression that are visible																						
A		•	○	•	○	•	P	•	○	•	○	•	○		○	•	○	•	○	•	○	•
B	○	•	○	•	○	•	○	•	○	•	○	•	○	P	○	•	○	•	○	•	○	•
C	○	•	○	•	○	•	P	•	○	•	○	•	○	P	○	•	○	•	○	•	○	•
D	○	•	○	•	○	•	○	•	○	•	○	•	○	•	○	•	○	•	○	•	○	•
E			○		○	•		•	○	•		P			○		○	•	○		P	
F	P	•	○		○	•	○	•	○	•	○	•	○		○		○	•	○	•	○	•
G	P	•	○		○	•	○	•	○	•	○		○		○		○	•	○	•	○	•
H	P	•	○		○	•	○	•	○	•	○	•	○	P	○	P	○	•	○	•	○	•

○, ESDA^2-positive results; •, EDPL-positive results; P, partially visible.

FIG. 2—*Footwear impression lifted by the Electrostatic Detection Apparatus[2] from a sheet of paper originally placed on a nylon carpet when the footwear impression was made.*

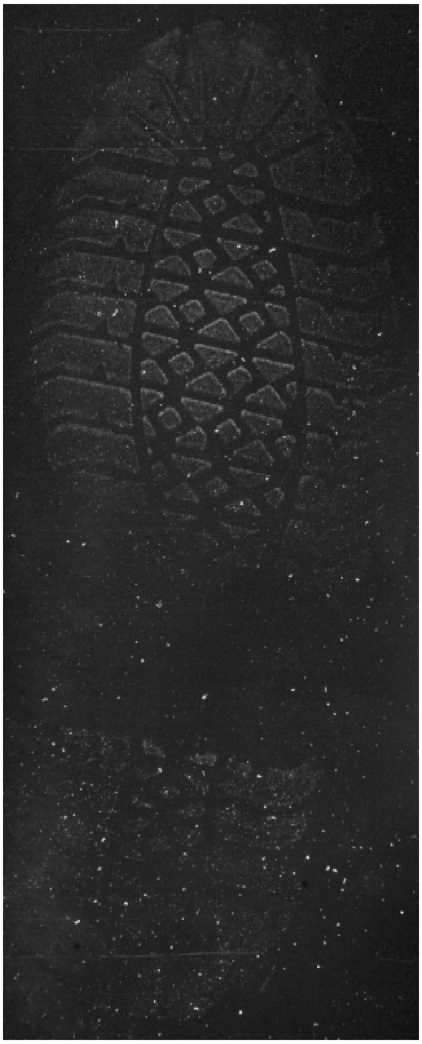

FIG. 3—*Footwear impression lifted by the Electrostatic Dust Print Lifter, after the sample was processed by the Electrostatic Detection Apparatus[2], from a sheet of paper placed on a nylon carpet when the footwear impression was made. Note: the image is reversed.*

impression placed on the paper over the industrial carpet (Table 1). However, the highest numbers of areas observed on the impression were present on the paper placed over the nylon carpet (Table 1) (Fig. 2). The footwear impressions developed on the paper placed over the industrial carpet, nylon carpet, and cardboard had similar results in the number of individual characteristics observed (Table 1). The 4-in. foam sample was the only sample that showed movement, specifically slippage, of the footwear impression. Corrugated lines present on the cardboard surface were transferred to the ESDA[2] image but did not interfere with the identification of any individual characteristics. The irregular surface texture of the asphalt and cement interfered with the ability to observe and identify some of the smaller individual characteristics. In some cases, the transfer of these irregularities onto the paper caused some of the individual characteristics to be hidden. In other cases, where these irregularities caused the shoe to not contact the paper, the areas could appear as individual characteristics to the untrained eye. Finally, with all uneven surfaces, the raised portions of the surface gave better impressions due to the support provided at those points. The deeper portions of the surfaces resulted in less visible impressions, which hindered the ability to identify individual characteristics in those areas.

The footwear impressions obtained using the EDPL after the ESDA[2] were of similar quality to those obtained when the ESDA[2] was used first (Table 1). The impressions obtained on the paper placed over the industrial carpet, nylon carpet, asphalt, and cardboard were of high quality (Table 1) (Fig. 3). In some cases, the EDPL was able to develop certain individual characteristics that were not observed when the ESDA[2] was used (Table 1). There were also instances when some individual characteristics were visualized when the ESDA[2] was used first, but those same characteristics were not observed when the EDPL was used subsequently (Table 1).

Sample impressions developed using the EDPL first resulted in the ability to identify similar characteristics as those observed when the ESDA[2] was used first, but with better detail, clarity, and contrast (Table 2). The increased detail of each impression allowed for the identification of many more individual characteristics, including the smaller nicks and cuts. The underlying defects of the asphalt and cement were well defined, which was also observed with the ESDA[2] samples, but these did not interfere with the identification of individual characteristics. The corrugated lines of the cardboard were more apparent as well, but also did not interfere in identification. The footwear impressions on the paper placed over the cardboard, industrial carpet, nylon carpet,

TABLE 2—*Individual characteristics identified with the EDPL-ESDA² method.*

Individual Characteristic	Linoleum	Industrial Carpet	Nylon Carpet	Ceramic Tile	Cardboard	1-in. Foam	4-in. Foam	Cement	Asphalt	Grass	Mulch
1	•				•			•	•		
2					•						
3		•	•	•	•	•	•	•			
4	•	•	•	• ○	•	•	•	•	•	•	•
5		•	•	•	•	•	•	•	•	•	•
6	•	•	•	•	•	•	•	•	•	•	•
7	•	•	•	•	•	•		•	•	•	•
8	•	•	•	•	•	•		•	•	•	
9	•	•	•	•	•	•	•	•	•	•	•
10	•	• ○	•		•	•	•	•	•	•	•
11	•	•	• ○	• ○	•	• ○	•	•	•	•	• ○
12		•	•		•					•	
13	•	•	•		•	•		•	•	•	•
14			•			•	•			•	
15		•			•				•	•	
16	•	•	•	•	•	•	•	•	•	•	•
17			•		•						
18		•	•	•	•	•	•	•	•	•	
19	•	•	•	•	•	•	•	•	•	•	•
20	•	•	•	•	•	•	•	•	•	•	•
21	•	•	•		•			•			•
22	•	•	•		•	•	•	•		•	•
23	•	•	•		•	•	•	•		•	•
24	•	•			•	•	•	•		•	
25	•	•			•	•		•		•	•
Sections of impression that are visible											
A	•	•	•	•	•	•	•	•	•	•	•
B	•	• ○	• ○	• ○	• ○	• ○	•	•	•	•	• ○
C	• ○	• ○	• ○	•	•	• ○	•	•	•	• ○	• ○
D	•	• ○	• ○	• ○	•	• ○	•	•	•	•	• ○
E	•	•	•	•	•	•	•	•	•	•	•
F	•	•	• ○	•	• ○	•	•	•	•	•	•
G	• ○	•	• ○	•	•	•	•	•	•	• ○	•
H	•	•	• ○	•	•	•	•	•	•	•	•

○, ESDA²-positive results; •, EDPL-positive results; P, partially visible.

cement, and grass surfaces yielded the best impressions with the most individual characteristics observed (Table 2) (Fig. 4).

The footwear impressions obtained when the ESDA² was used after the EDPL were of little to no value (Table 2). Only very faint, partial impressions were visible. Interestingly, the images developed were reversed impressions, appearing white over a gray background, instead of the usual gray impression over a white background (2). This reversal in color has also been observed when impressions are developed on paper that bears inked writing. The inked writing appears as white lines on a gray background, instead of black lines. This color reversal was observed on all the impressions obtained using the ESDA² after the EDPL (Fig. 5).

Impressions obtained using the ESDA² first were of higher quality than those obtained using the ESDA² second (Tables 1 and 2). The impressions obtained using the ESDA² first were lighter and more faded around the perimeter (Fig. 2) when compared with the results when processed by the EDPL first (Fig. 4). Because a majority of the characteristics used for comparison were present on the perimeter of the impression, many of the smaller characteristics in the perimeter were obscured or not present (Table 1). The larger characteristics in the center of the impression were still identifiable (Table 1). A positive identification was still possible on the paper placed over most of the substrates when the ESDA² was used before the EDPL (Fig. 6).

Sensitivity tests performed on both methods revealed the footwear impression developed on the first sheet processed by the ESDA² was less sensitive than the footwear impression developed by the EDPL on the first sheet (Table 3). The first of the 10 sheets of paper stepped on and processed with the ESDA² resulted in a high-quality image with 56% of the individual characteristics identified (Table 3) (Fig. 7). No footwear impression was developed on the second sheet of paper (Table 3) (Fig. 7). Therefore, no other sheets were processed with the ESDA².

Similarly, the first sheet of paper stepped on and developed with the EDPL resulted in a very detailed impression, with 80% of the individual characteristics identified (Table 3). The 10th sheet processed with EDPL resulted in a very detailed impression, with 84% of the individual characteristics being identified (Fig. 7).

Discussion

Several problems were encountered during development of the impressions, which were associated with the specific methods of development. When developing images with the ESDA² using the cascade developer, the toner is deposited heavier on the lifted side of the sample, causing uneven distribution of toner across the image. Bubbles formed during the application of the adhesive fixing film, which distorted the impression and may have hindered the identification of individual characteristics. The lifts obtained using the EDPL did not present any major obstacles as long as they were photographed immediately after development. The largest problem encountered with the use of the EDPL is the fragile nature of the dust impression. Anything brushing against the impression could remove or obscure the image. This problem remains even in storage of the impression. A second problem is the residual charge of the Mylar film, which will attract excess dust. The charge will

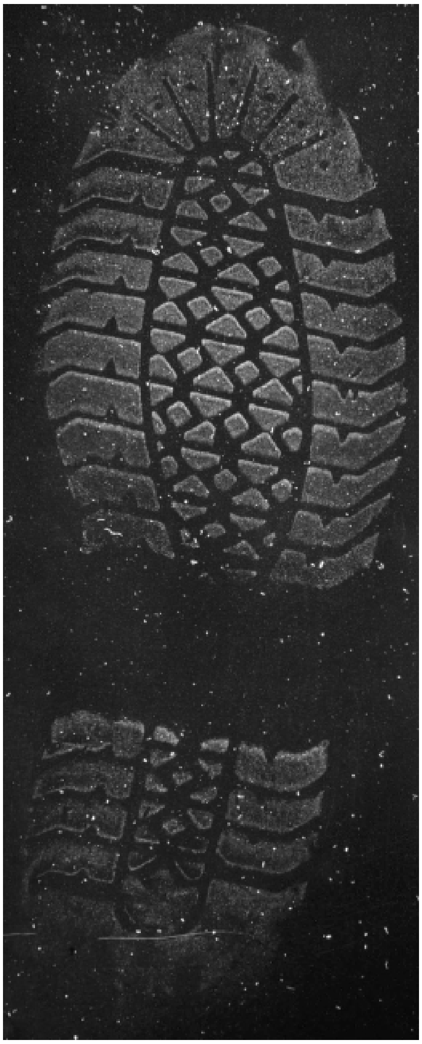

FIG. 4—*Footwear impression lifted by the Electrostatic Dust Print Lifter from a sheet of paper placed on a nylon carpet when the footwear impression was made. Note: the image is reversed.*

FIG. 5—*Footwear impression lifted by the Electrostatic Detection Apparatus^2, after the sample was processed by the Electrostatic Dust Print Lifter, from a sheet of paper placed on a nylon carpet when the footwear impression was made.*

also decrease overtime and the impression can be lost. Therefore, the impression must be photographed shortly after collection.

Also worthy of note was a color reversal that was observed on the footwear impression developed when the ESDA^2 was used after the EDPL. Theories have been proposed as to why inked writing is treated in the opposite way from the indented writing, but this process is not fully understood (2). Therefore, the reason why the footwear images developed as reversed impressions is unknown at this time. Processing the samples first using the EDPL could change the properties of the paper when it is subjected to an electrostatic charge, resulting in the observed reversed images. Personal communication with Foster & Freeman (K. Kovarik and P. Forder, March 2005) indicated the footwear impressions developed by the ESDA^2 might be originating from the surface disturbance provided by the pattern of dust particles on the paper surface rather than the indentation alone. This is based on the idea that indentations resulting on paper from a shoe coming into contact with it are a form of macroscopic impact printing rather than the microscopic form resulting from handwriting. This macroscopic form would consist of two distinct parts: a true indentation and surface disturbance by the pattern of dust particles. Therefore, the ESDA^2 may not develop the footwear impression after the EDPL is used because the EDPL removed the pattern of dust particles. The reason that reversed images and low to no quality impressions were developed when using the ESDA^2 after the EDPL

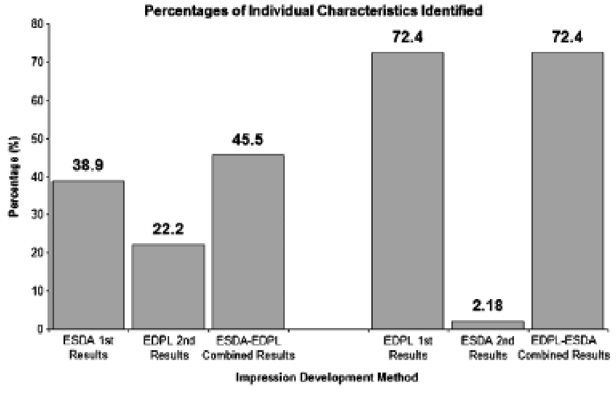

FIG. 6—*Percentages of individual characteristics identified using only the Electrostatic Detection Apparatus^2 (ESDA^2), the Electrostatic Dust Print Lifter (EDPL) after the ESDA^2, a combination of the ESDA^2 and the EDPL in order, only the EDPL, the ESDA^2 after the EDPL, and a combination of the EDPL and the ESDA^2 in order.*

TABLE 3—*Individual characteristics identified in sensitivity tests.*

	ESDA^2		EDPL	
Individual Characteristic	First Sheet	Second Sheet	First Lift	Tenth Lift
1				
2				
3			•	•
4			•	•
5	○		•	•
6	○		•	•
7	○		•	•
8	○		•	•
9	○		•	•
10	○		•	•
11	○		•	•
12			•	•
13		N/A	•	•
14				
15				
16	○		•	•
17				•
18	○		•	•
19			•	•
20	○		•	•
21	○		•	•
22	○		•	•
23	○		•	•
24	○		•	•
25			•	•
Sections of impression that are visible				
A	○		P	•
B	○		•	•
C	○		•	•
D	○		•	•
E	○		•	•
F	○		•	•
G	○		•	•
H	○		•	•

○, ESDA^2-positive results; •, EDPL-positive results.

is beyond the scope of this study. To find out why this occurs, more research needs to be conducted.

The impressions obtained using the EDPL first were of higher comparative value than the images obtained using the ESDA^2 first. On average, 72% of the individual characteristics from the known impression were identified on images developed when the EDPL was used first (Fig. 6). In addition, the EDPL is more user friendly due to the fact that it is portable, quicker to use, easier to use, and has better versatility with multiple surface types. If an EDPL is unavailable for the development of a footwear impression on paper, it is possible to obtain a satisfactory impression using the ESDA^2; however, the use of an EDPL is highly recommended.

If a footwear impression becomes apparent through the process of using the ESDA^2, the EDPL may still be utilized to elicit a satisfactory impression. When the methods were used in this order, 45.5% of the individual characteristics were identified by combining the results from both development techniques (Fig. 6).

On the other hand, if a footwear impression becomes apparent through the process of using the EDPL, the ESDA^2 may still be utilized to obtain an impression. However, the footwear impression developed with the ESDA^2 may be of little to no value. When the methods were used in this order, 72% of the individual characteristics were identified by combining the results from both development techniques. The majority of the individual characteristics were identified from the results of the EDPL (72%) compared with the ESDA^2 (2.18%) (Fig. 6).

Therefore, if one must choose between the EDPL and the ESDA^2, the EDPL should be used instead of the ESDA^2 due to the ability to obtain higher quality images. The EDPL should also be chosen over the ESDA^2 because of its versatility and mobility. If an obvious indented footwear impression is present on a sheet of paper, the EDPL should be used instead of the ESDA^2. If for some reason, the analyst decides to use the ESDA^2, the ESDA^2 should be used before the EDPL and not vice versa. This order results in higher quality images from both techniques, which is desirable. Therefore, the EDPL should be used instead of the ESDA^2 due to the superior results obtained using the EDPL (Fig. 6).

The sensitivity tests conducted using the EDPL indicated the impression lifted would be of higher quality as the amount of dust transferred onto surfaces becomes more trace (Fig. 7). This may be due to excess dirt that can obscure smaller individual characteristics, preventing their identification.

The sensitivity tests conducted using the ESDA^2 indicated that footwear impressions would only be developed on the top sheet of paper if sheets were stacked. The lack of an impression on the sheets under the top sheet of paper could be attributed to the ESDA^2 only detecting small, microscopic changes, such as those made when writing (7), versus the larger impressions made by the tread of the shoe.

In conclusion, the EDPL produced much higher quality footwear impressions than the ESDA^2. It is recommended that the EDPL be used when developing latent footwear impressions on paper, whether the footwear impression is indented onto the paper or not. If both methods are used, it is recommended that the ESDA^2 be used before the EDPL to obtain satisfactory results using both techniques.

This study indicates that the ESDA^2 will only provide good results on the top sheet of paper if a footwear impression is present on a stack of papers. It also indicates the EDPL will obtain higher quality footwear impressions as the amount of dust residue decreases on a surface. Further research in these areas is needed to determine the specific reason why the ESDA^2 does not develop footwear impressions on any papers in a stack except the top sheet and why the quality of the footwear impression lifted by the EDPL is higher as the amount of residue decreases.

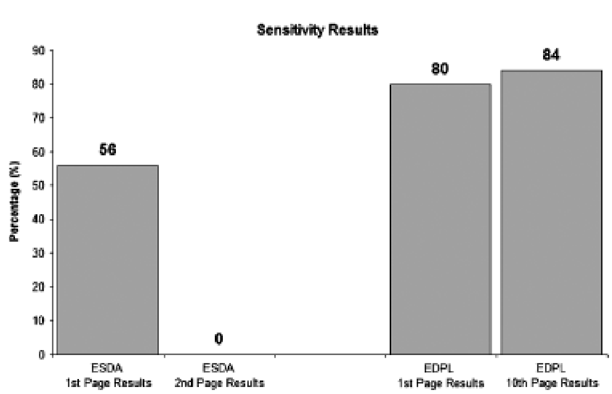

FIG. 7—*Percentages of individual characteristics identified when using the Electrostatic Detection Apparatus (ESDA^2) on a stack of paper and the Electrostatic Dust Print Lifter (EDPL) on 10 sheets of paper consecutively.*

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