A Method for Determining the Condition of an ESDA or IMEDD

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Many Forensic Document Examiners (FDEs) have taken steps to prepare their laboratories for accreditation. One important requirement of this process involves the testing of equipment to ensure it is in good working order and capable of providing quality results. Two instruments used to decipher indented impressions on paper are the Electrostatic Detection Apparatus (ESDA) and the Indentation Materializer Electrostatic Document Device (IMEDD). The results produced by these instruments can vary due to a number of causes including: unfavourable ambient conditions (low relative humidity), weak corona discharge, a dirty corona wire, insufficient application of toner and weak pressure generated by the vacuum pump. A simple device is described that enables the ESDA or IMEDD operator to repeatedly produce constant impressions on paper test strips. The test strip is subjected to the same experimental conditions as the questioned document and is placed on the platen each time the instrument is used. The degree to which impressions on the test strip are recovered is a function of the ambient conditions and the instrument's condition. If test results lie outside an acceptable range, the instrument must be repaired or the test postponed until environmental conditions are favorable.

Introduction

An electrostatic method for detecting indented impressions in paper was introduced by Morantz, Foster and Ellen (Baier, 1983) in 1968. During the same year, Foster + Freeman commenced selling their Electrostatic Detection Apparatus (ESDA) which provided a more sensitive technique for detecting indented writing than previous conventional methods.

During the early 1990's, Kinderprint, a Swedish company, began production of an Indentation Materializer Electrostatic Document Device (IMEDD). Like the ESDA, the IMEDD provided document examiners with the ability to view faint indented impressions in paper. Lightning Powder Company later distributed this instrument under the trade name "Docubox."

Despite the unsurpassed effectiveness of these two instruments, recent studies indicate that results from ESDA and IMEDD examinations can suffer for a number of reasons (Noblett and James, 1983; Giles, 1988; D'Andrea, Mazzella, Khanmy, and Margot, 1996; Riebeling and Kobus, 1994). Low relative humidity (rH) is the most frequently cited cause (Pearse and Brennan, 1996), although other factors which are largely related to the condition of the instrument may contribute to poorly developed impressions. These influences include:

- a defective pump
- leaks in vacuum or pressure lines
- a dirty corona wire or faulty power supply
- uneven distribution of developing powder, or,
- operator error (not following proper procedures)

When decipherable impressions are detected on a document using the ESDA or IMEDD, the test is usually considered to be successful. However, what if no impressions were detected? Can the examiner assume that the tested document contains no indentations or could the outcome have been influenced by some of the limiting factors mentioned above? Unless both the equipment and test conditions are conducive for obtaining satisfactory results, the possibility that critical evidence was overlooked cannot be ruled out.

A few years ago, an American Society for Testing and Materials (ASTM) subcommittee looked into the possibility of developing tests that would confirm if certain equipment used by FDEs is in good operating condition. Of particular importance was a method for testing the ESDA and IMEDD. Although the subcommittee identified some theoretical solutions, none of these were transformed from conceptual models to working examples.

Riebeling and Kobus (1994) stress the importance of using a standard impression as a quality control measure for ESDA examinations. Some document examiners have adopted the practice of producing indentations on a paper strip and placing it on the platen along with the document being tested. The development of indentations on the paper strip provides some assurance that the instrument was functioning properly and that experimental conditions were favorable. While this represented an improvement, it failed to assess the instrument's ability to recover less than ideal impressions. Further modifications were clearly necessary.

Methods and Materials

Most theoretical models considered by the ASTM subcommittee involved the application of a weight fixed to a pen or stylus that could be brought across a sheet of paper thereby producing an indented impression of relatively constant depth. In theory, these devices would be designed to produce impressions that only instruments in good working condition would be capable of restoring. While such innovations would represent an improvement over random impressions scribbled by the examiner, the designs were not capable of producing impressions of variable depth similar to those encountered in actual case work.

It was decided that some form of metal wedge with a uniform slope would be ideal for generating paper impressions with varying depths. A ballpoint pen was chosen as the best instrument for producing the sample impressions because it is the most common writing instrument encountered in case work. The pen could be mounted in a holder that would serve to guide it along a predetermined path, keeping its slope constant relative to the surface of the paper.

A prototype was constructed from a plate of brushed aluminum measuring approximately 20 cm long x 5.5 cm wide x 0.5 cm thick. The plate was given a large surface area to minimize compression of the paper as sample impressions were being prepared. A slot 18.5 cm long and 1 cm wide was removed from the center of the plate. Next, a shoulder 2 cm wide was milled out of the center of the plate. This grooved shoulder followed a constant slope starting 0.0020 cm from the top surface of the plate at one end of the slot to 0.0040 cm at the opposite end.

A pen holder was fabricated from a cylinder of Delrin® hard plastic. The cylinder diameter was reduced to slightly less than the width of the slot in the plate. The upper portion of the plastic cylinder was turned to fit inside the milled groove of the plate. Finally, a hole was drilled through the center of the cylinder to accommodate the nose of a Bic "round stic" ballpoint pen. The finished plate and pen holder are shown in Figure 1. The bottom of the pen holder with the ballpoint pen in position is shown in Figure 2 and the upper surface of the aluminum plate appears in Figure 3.

The Experiment

Two validation studies were conducted to determine if impressions produced by this device were consistent and suitable for testing ESDAs and IMEDDs.

Study 1:

In the first study, twenty-six impressions were produced on a sheet of paper using the following procedure.

- Two pieces of 8.5" x 11" clean 20# bond paper were placed on a flat surface under the plate.
- The plate was centered in contact with the upper sheet.
- Starting at one end of the plate, the pen and holder were drawn across the plate while applying constant downward pressure.
- The plate was moved 5 mm lower and a second impression was produced. This step was repeated until twenty-six ink lines were generated.
- The paper test strips produced by this method were then placed in a humidity chamber for approximately 10 minutes.

The two pieces of paper were then tested. The depth of five ink lines on the top sheet of paper

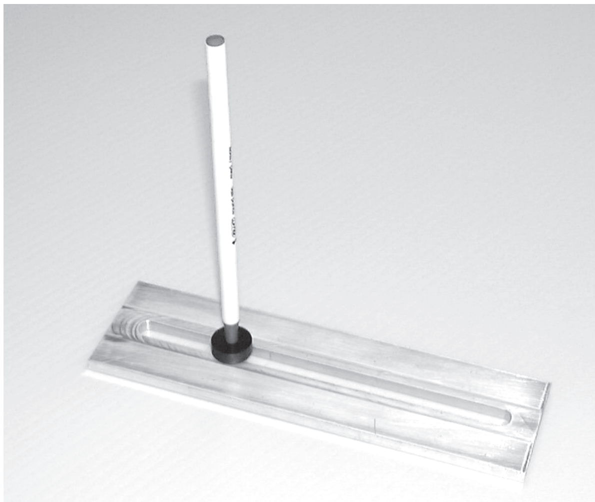

Figure 1. Pen holder resting on plate

Figure 2. Bottom surface of pen holder

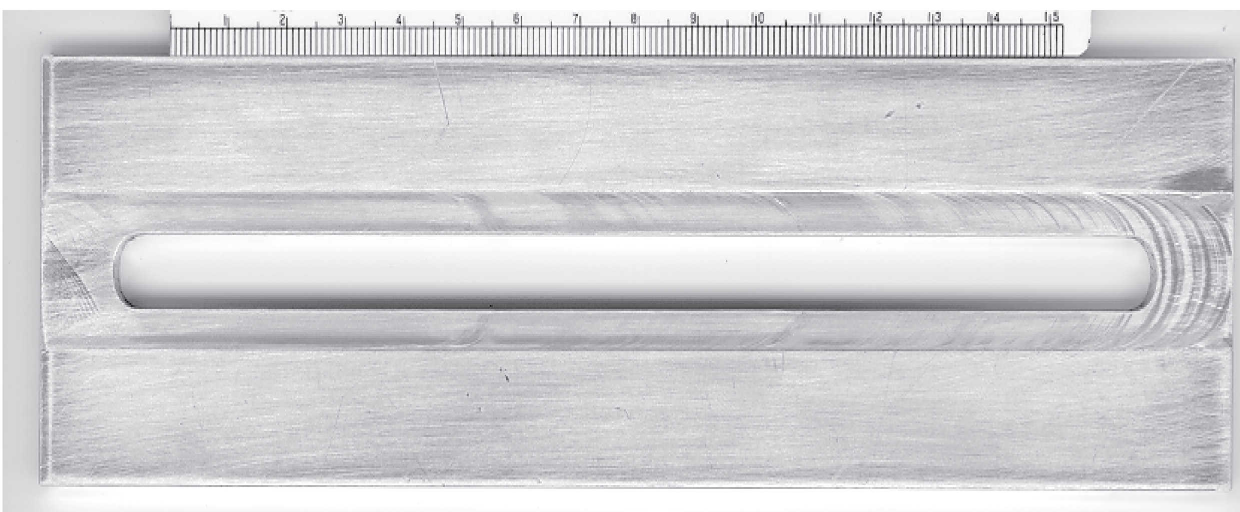

Figure 3. Aluminum base plate showing the slot and milled trough that accommodates the pen holder.

were measured at three locations using a confocal laser scanning microscope. These measurements were analyzed statistically. The indented impressions in the bottom sheet were subjected to an ESDA examination. The quality of developed impressions were examined for consistency. Inked and indented impressions from the two sheets of paper are shown in Figures 4a and 4b on the following page.

Study 2:

The second study involved generating an impression on 4 separate strips of paper. These test strips were used to test three ESDA and two IMEDD instruments. The four test strips were prepared using the method described above. All four strips were positioned on each instrument and processed simultaneously. In the case of the ESDA instru-

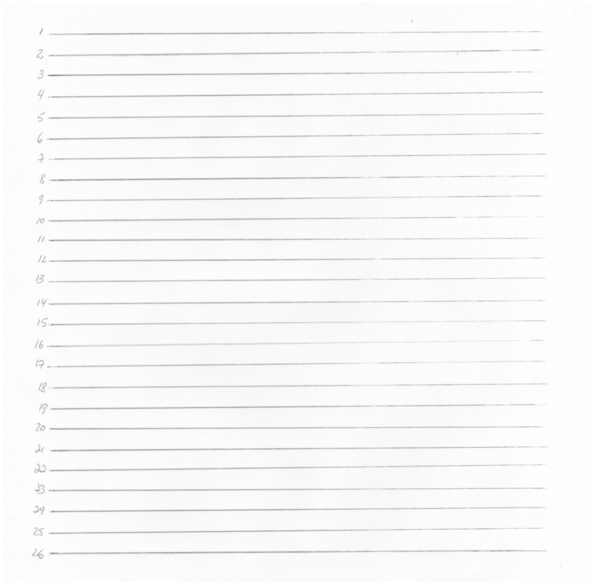

Figure 4a. Twenty-six inked lines produced on the top sheet.

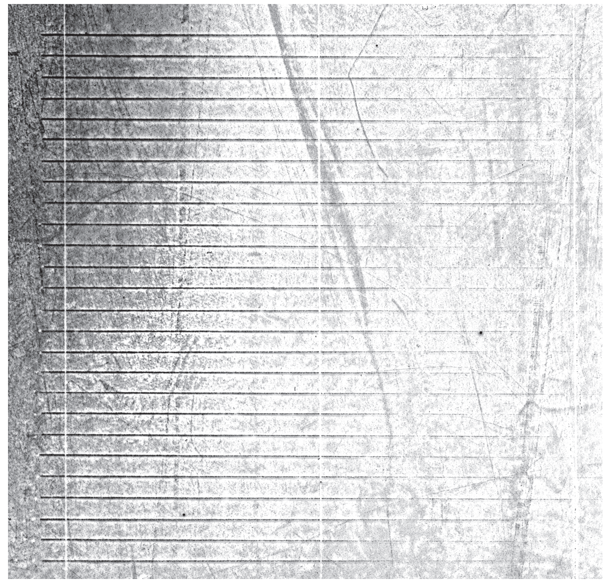

Figure 4b. Twenty-six lines restored on the underlying sheet.

ments, developing powder was applied using both aerosol and cascade methods. Brushing and cascade/canister methods were used to develop latent images with the IMEDD instruments. The results were then examined and compared for consistency.

Results and Discussion

Some variances were noted in the last 2 cm (0.75 inches) of some visible ink lines and their corresponding developed impressions. This phenomena is believed to be due to small differences in downward pressure applied to the pen holder when the impressions were produced. Slight irregularities in the supporting surface of the table may also have played a minor role. In each of the twenty-six instances, the developed impressions were 15 cm (6 inches) in length or longer.

The depth of ink lines 1, 5, 10, 15 and 20 on the first sheet of paper was measured at three locations: near the start, at the middle and near the end of each line. These measurements appear in Table 1 and show the variability of impressions at specific points. The variance and standard deviation of the depth of impressions at the three locations were also calculated.

Line Number	Start (x = 0.7 cm)	Middle (x = 8.4 cm)	End (x = 16.1 cm)
1	51.5 micron	40.3 micron	11.2 micron
5	49.7 micron	39.4 micron	10.6 micron
10	48.6 micron	38.7 micron	10.9 micron
15	50.4 micron	40.8 micron	10.4 micron
20	51.6 micron	39.5 micron	10.7 micron
Population Variance	1.26	0.82	0.31
Standard Deviation	1.13	0.73	0.27

Table 1. Impression depths of five ink lines measured at their start, middle, and end points.

The data presented in Table 1 shows that the depths of lines at their mid-points are not as great as they should be. If the trough in the aluminum plate was milled at a constant slope, these depths should be in the order of 30 micron. The measurements suggest that either the plate was not positioned correctly or it shifted during the milling operation. This event did not compromise the study and the problem can be corrected by removing additional material from the plate.

The reported variation with respect to impression depths does not adversely affect the utility of this device. These variances are attributed to the non-homogeneous nature of paper and the presence of large, irregular fibers in some areas of measurement. These factors made it difficult to estimate the horizontal plane of the paper surface and the bottom of the trough using the confocal laser scanning microscope.

Results from the second validation study were quite consistent. The indented impressions produced by the five instruments (3 ESDAs and 2 IMEDDs) measured 15 cm in length or longer. The quality of restored impressions varied as did successive trials from the same instrument. These variances were limited to the final 2 cm of the restored lines. It is likely that different operator techniques, ambient conditions, toner application methods, and instrument conditions influenced the results somewhat.

Conclusion

Many laboratories are participating in accreditation programs offered by either the International Standards Organization (ISO) or the American Society of Crime Laboratory Directors Labotatory Accreditation Board (ASCLD/LAB). ISO guidelines (Mathers, Marshall, Callibor, and Phipps, Editors, 1994) specify that certain steps must be taken to ensure equipment is calibrated and in good working order. ASCLD documentation (1994) contains similar provisions to ensure laboratory test equipment is capable of producing quality results.

A "fitness for use" test should be performed each time a document is examined for latent indentations using an ESDA or IMEDD instrument. This precaution will:

- confirm that the instrument is in good working condition,
- provide more precise control over the deposition of developing powder, and
- ensure that the experimental conditions are conducive to yielding satisfactory results.

The plate and pen holder described in this paper addresses each of these issues by producing paper test strips that have impressions of constant pitch. The use of this simple device can enhance the reliability of negative ESDA and IMEDD results.

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