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Standard Guide for Non-destructive Examination of Paper¹

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^{e1} Note—Section 2 was editorially corrected in April 2010.

1. Scope

1.1 This guide provides procedures that should be used by forensic document examiners (see Guide E444) for non-destructive examinations of paper.

1.2 These procedures are applicable whether the examination is of questioned and known items or of exclusively questioned items.

1.3 These procedures include evaluation of the sufficiency of the material available for examination.

1.4 The particular methods employed in a given case will depend upon the nature of the material available for examination.

1.5 This guide may not cover all aspects of particularly unusual or uncommon examinations of paper samples.

1.6 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 ASTM Standards:²

- E444 Guide for Scope of Work of Forensic Document Examiners
- E1422 Guide for Test Methods for Forensic Writing Ink Comparison
- E1732 Terminology Relating to Forensic Science

3. Terminology

3.1 Definitions:

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² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

3.1.1 For definitions of terms in this guide, refer to Terminology E1732.

3.2 Definitions of Terms Specific to This Standard:

3.2.1 *fluorescence, n*—a process by which radiant energy is absorbed and reradiated at other, usually longer, wavelengths.

3.2.2 *infrared (IR), n*—referring to radiant flux having wavelengths longer than the wavelengths of light, usually wavelengths from about 780 nm to about 1 mm. E284

3.2.3 *infrared luminescence (IRL), n*—the emission of radiant energy during a transition from an excited electronic state of an atom, molecule, or ion to a lower electronic state (fluorescence or phosphorescence, or both), where the spectrum of the excitation source is in the ultraviolet (UV) or visible region of the electromagnetic spectrum, or both, and the spectrum of the emitted energy is in the far red or infrared (IR) region of the electromagnetic spectrum. E1422

3.2.4 *luminescence, n*—the emission of radiant energy during a transition from an excited electronic state of an atom, molecule, or ion to a lower electronic state. E1422

3.2.5 *opacity, n*—the property of paper that prevents the transmission of light.

3.2.6 *ultraviolet (UV), n*—referring to radiant flux having wavelengths shorter than the wavelengths of light, usually wavelengths from about 10 nm to 380 nm. E1422

3.2.6.1 *Discussion*—Long-wave UV usually refers to the spectral range of UV-A, with wavelengths from about 315 nm to 380 nm. Short-wave UV usually refers to the spectral range of UV-C, with wavelengths from 100 nm to 280 nm.

3.2.7 *watermark, n*—a localized modification of the formation and/or opacity of a sheet of paper so that a pattern, design, or word group can be seen in the dry sheet when viewed using side lighting or transmitted light.

4. Significance and Use

4.1 The procedures outlined here are grounded in the generally accepted body of knowledge and experience in the field of forensic document examination. By following these procedures, a forensic document examiner can reliably evaluate the physical similarities or differences between papers that



can lead to a determination as to whether papers originated from the same source.

5. Interferences

5.1 Certain items submitted for examination may have inherent limitations that can interfere with the procedures in this guide. Limitations should be noted and recorded.

5.2 The condition of a paper sample may make it unsuitable for some types of examinations (for example, item(s) that are water soaked, stained, soiled, charred, or finely shredded).

5.3 Storage conditions such as exposure to light, heat, or moisture can affect the appearance of paper during certain tests.

5.4 Chemical processing for latent prints generally interferes with non-destructive paper examination. Paper examinations should be conducted prior to any chemical processing.

5.5 Items should be handled as little as possible prior to and during paper examinations to prevent contamination such as the introduction of latent prints. The use of clean cloth gloves is recommended.

5.6 In the paper manufacturing process reams of paper and other paper products can be comprised of sheets from one or more rolls of paper. Differences in paper characteristics may be present in individual sheets from the same ream or product and, therefore, must be considered when assessing color, thickness, UV fluorescence, IRL, opacity, surface texture and printed material (see 7.6, 7.7, 7.8, 7.10, 7.11, and 7.17).

6. Equipment and Requirements

6.1 Appropriate light source(s) of sufficient intensity to allow fine detail to be distinguished.

NOTE 1—Natural light, incandescent or fluorescent sources, transmitted illumination and fiber optic lighting systems are generally utilized. Side lighting and vertical incident lighting may be useful in a variety of situations.

6.2 Magnification sufficient to allow fine detail to be distinguished.

6.3 Measuring Devices:

6.3.1 Micrometer capable of measuring in increments of 0.02 mm or 0.001 inch. Ruler measuring at least 300 mm long, marked in increments of 0.5 mm or less, or measuring at least 12 in. long, marked in increments of $\frac{1}{64}$ in. or less.

6.3.2 Scale capable of measuring 0.001 g.

6.4 IR image conversion device or system with appropriate light sources and filters for use in IR and IRL examinations.

6.5 Electrostatic detection device to examine for indented impressions.

6.6 Long and short wave UV sources.

6.7 Materials sufficient to evaluate the relative opacity of paper.

6.8 Other apparatus as appropriate.

6.9 Imaging or other equipment for recording observations as required.

6.10 Sufficient time and facilities to complete all applicable procedures.

7. Procedures

NOTE 2—All procedures shall be performed when applicable and noted when appropriate. These procedures need not be performed in the order given.

7.1 Examinations performed, relevant observations, and results shall be documented.

7.2 At various points in these procedures, a determination that a particular feature is not present or that an item is lacking in quality or comparability may indicate that the examiner should discontinue or limit the procedure(s). It is at the discretion of the examiner to discontinue the procedure at that point and report accordingly or to continue with the applicable procedures to the extent possible. The reasons for such a decision shall be documented.

7.3 Determine whether the examination is a comparison of questioned paper sample(s) or a comparison of a questioned paper sample(s) with a known paper sample(s).

NOTE 3—For the purpose of this guide, two samples will be compared. These samples may refer to known and questioned specimens, or exclusively questioned specimens.

7.4 Determine whether the submitted paper samples are suitable for comparison. If not suitable for comparison, discontinue the procedure and report accordingly.

7.5 Examine the paper samples with transmitted light.

7.5.1 Record any watermarks present.

7.5.1.1 When identifying a manufacturer or dating a paper sample by the use of a watermark, refer to laboratory and published industry resources. If necessary, contact the appropriate paper manufacturer for further information.

7.6 Examine the color of the paper samples. Refer to Interferences section 5.6.

7.6.1 Determine the significance of any differences observed.

7.7 Measure the thickness of the paper samples with a micrometer. An averaging of measurements made at the center and opposite edges of each paper sample, is recommended. Refer to Interferences section 5.6.

7.8 Examine the paper samples for UV fluorescence and IRL. Refer to Interferences section 5.6.

7.9 Examine the samples for chemical or other contamination, alterations, and carbonless paper transfers.

7.10 Examine the relative opacity of the paper samples. Refer to Interferences section 5.6.

7.11 Examine the surface texture of the paper samples (for example, smoothness, patterns). Refer to Interferences section 5.6.

7.12 Measure the paper samples with a ruler, recording length and width measurements.

7.13 Measure the weight of the paper sample. The relative basis weight can be compared by dividing the weight of the paper by its area.

7.14 Examine corners of the paper samples and evaluate angles (for example, squared, curved, rough finish).

7.15 Examine edges of the paper samples with magnification, or UV sources, or both for remnants of binding, adhesives, or padding material.

7.16 Examine edges of the paper samples for manufacturing markings (for example, cut marks, striations or coloration). Evaluate for proper orientation of each page with all other pages.

7.17 Examine paper samples with lines or other printed material with appropriate instruments capable of magnification, IR, IRL, and UV examinations. Measure line length, spacing, and other printed material. Examine for broken or deformed patterns. Refer to Interferences section 5.6.

7.18 Examine the paper samples for the presence of security features (for example, planchettes or security fibers).

7.19 Examine the samples for carbonless paper chemicals and form printing image quality that can indicate a carbonless system.

7.20 Locate and record any trace materials (for example, opaquing solution, correction strips, tape, or other materials) on the paper samples.

7.21 Examine the paper samples for surface damage due to abrasions, handling, storage, or other physical changes. If folds, creases, crimp markings, fiber disturbances, or other relevant characteristics, are located on any sample, determine the significance as they relate to other samples.

7.22 Examine the paper samples for size and spacing of staples and staple holes. If the pages of the documents are stapled together, determine any pattern similarities or differences between the number and pattern of staple holes present.

7.22.1 Prior to the removal of any staples, record the position of the staple holes relative to the existing staple(s).

7.22.2 Coordination with the submitter of the evidence may be advisable before removing any staples.

7.23 Examine the paper samples for perforations, hole punches, or other torn portions.

7.24 Examine the surfaces of the paper for indentations such as handwriting, clipboard marks, paper clip impressions, and other extraneous markings.

7.25 Evaluate similarities, differences, and limitations. Determine their significance individually and in combination and reach a conclusion.

8. Report

8.1 Conclusion(s), or opinion(s), or other finding(s) resulting from the procedures in this guide may be reached once sufficient examinations have been conducted.

8.2 The bases and reasons for the conclusion(s) or opinion(s) should be included in the examiner's documentation and may also be included in the report.

8.3 Once examinations and evaluations have been completed, reports may include, but are not limited to, the following types of conclusion(s), opinion(s), or finding(s):

8.3.1 Evidence such as indentations, contaminants, physical similarities, etc., associates the paper samples as being attached, handled by, or originating from the same source.

8.3.2 The paper samples originate from or share the same manufacturer source (mill, post-mill processing, binding, printing, trimming, packaging and distribution processes) or post-manufacturer source (consumer or user level).

8.3.3 The paper samples can neither be associated nor disassociated as originating from or sharing the same source.

8.3.4 The paper samples did not originate from or share the same source.

8.3.5 Evidence such as indentations, contaminants, physical similarities, etc., associates the paper samples as being attached, handled by, or originating from the same source.

9. Keywords

9.1 forensic document examination; forensic sciences; non-destructive paper examination; paper; questioned documents; watermark

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- (2) Brunelle, Richard L. and Robert W. Reed, *Forensic Examination of Ink and Paper*, Charles C. Thomas, Springfield, IL, 1984.
- (3) The Mead Corporation, *Paper Knowledge*, 1999.
- (4) Saferstein, Richard, *Forensic Science Handbook*, Regents/Prentice Hall, Englewood Cliffs, NJ, 1982.

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