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Standard Guide for Forensic Examination of Fabrics and Cordage¹

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1. Scope

1.1 This guide is intended to assist individuals and laboratories that conduct examinations of fabrics and cordage for the purposes of analyzing and comparing types of fabric, cordage and damage. A complete characterization of the fabrics, including their construction and other materials used in the assemblage of a textile (for example, sewing thread), is a critical component of a comprehensive forensic fabric or cordage examination.

1.2 The values stated in inch-pound units are to be regarded as standard. No other units of measurement are included in this standard.

1.3 *This standard is intended for use by competent forensic science practitioners with the requisite formal education, discipline-specific training (see Practice E2917), and demonstrated proficiency to perform forensic case work*

1.4 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*²

D123 Terminology Relating to Textiles

E620 Practice for Reporting Opinions of Scientific or Technical Experts

E1459 Guide for Physical Evidence Labeling and Related Documentation

E1492 Practice for Receiving, Documenting, Storing, and Retrieving Evidence in a Forensic Science Laboratory

E2224 Guide for Forensic Analysis of Fibers by Infrared Spectroscopy

E2227 Guide for Forensic Examination of Non-Reactive Dyes in Textile Fibers by Thin-Layer Chromatography (Withdrawn 2022)³

E2228 Guide for Microscopical Examination of Textile Fibers

E2917 Practice for Forensic Science Practitioner Training, Continuing Education, and Professional Development Programs

2.2 *AATCC Standards:*⁴

AATCC Test Method 20: Qualitative Test Method 20–2007
Fiber Analysis: Qualitative

2.3 *Other Documents:*

ISO 17025 Testing and calibration laboratories⁵

3. Terminology

3.1 *Definitions*—For definitions of terms used in this guide, refer to Terminology **D123**.⁷

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *braid, n*—the intertwining of strands in a braiding process to produce a rope structure.

(1)⁶

3.2.2 *cord, n*—a twisted or formed structure composed of one or more single or plied filaments, strands, or yarns of organic polymer or inorganic materials.

D123

3.2.2.1 *Discussion*—Generally, cords have a diameter less than $\frac{3}{16}$ in.

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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 The last approved version of this historical standard is referenced on www.astm.org.

⁴ Available from American Association of Textile Chemists and Colorists (AATCC), P.O. Box 12215, Research Triangle Park, NC 27709-2215, http://www.aatcc.org.

⁵ Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

⁶ The boldface numbers in parentheses refer to a list of references at the end of this standard.

3.2.3 *cordage, n*—a collective term for twines, cords and ropes made from textile fibers and yarns.

(1)

3.2.4 *core, n*—a textile product (yarn, strand, small diameter rope, etc.) placed in the center of a rope and serving as a support for the strands around it.

(1)

3.2.4.1 *Discussion*—Core can be of any continuous construction including parallel strands, twisted strands or braided strands.

3.2.5 *course, n*—*in knitted fabrics*, a row of successive loops in the width direction of the fabric.

D123

3.2.6 *crown, n*—the raised portion of a strand in twisted cordage.

3.2.7 *exclusionary difference, n*—a difference in one or more characteristics between compared items that is sufficient to determine that the compared items did not originate from the same source, are not the same source, or do not share the same composition or classification.

3.2.7.1 *Discussion*—What is sufficient depends on the performance and limitations of the method used on the material in question.

3.2.8 *fabric, n*—*in textiles*, a planar structure consisting of yarns or fibers.

D123

3.2.9 *filament, n*—*in textiles*, a continuous fiber of extremely long length.

D123

3.2.10 *knitted fabric, n*—a structure produced by interlooping one or more ends of yarn or comparable material.

D123

3.2.11 *nonwoven fabric, n*—a textile structure produced by bonding or interlocking of fibers, or both, accomplished by mechanical, chemical, thermal, or solvent means and combinations thereof.

D123

3.2.12 *ply, n*—(1) the number of single yarns twisted together to form a plied yarn, or the number of plied yarns twisted together to form cord; (2) an individual yarn in a plied yarn or cord; (3) one of a number of layers of fabric; (4) the number of layers of fabric as a shirt collar, or of cord in a tire.

(2)

3.2.13 *rope, n*—a compact and flexible, torsionally balanced structure produced from strands which are laid, plaited, or braided together to produce a product which serves to transmit a tensile force between two points.

3.2.13.1 *Discussion*—Generally greater than $\frac{3}{16}$ in. diameter (1); a rope is made up of three or more strands.

3.2.14 *selvage, n*—the woven edge portion of a fabric parallel to the warp.

D123

3.2.15 *staple, n*—natural fibers or cut lengths from filaments.

D123

3.2.16 *strand, n*—(1) a single fiber, filament, or monofilament; (2) an ordered assemblage of textile fibers having a high ratio of length to diameter and normally used as a unit; includes slivers, roving, single yarns, plied yarns, cords, braids, ropes, etc.

(2)

3.2.16.1 *Discussion*—A strand is often multiple plies joined together. The terms “ply” and “strand” are not synonymous; cordage can have a single-plied strand, but not a stranded ply.

3.2.17 *thermoplastic, n*—a synthetic material that softens or melts at high temperatures.

3.2.18 *thread, n*—a slender strong strand or cord made by plying or twisting yarns, typically used for stitching.

3.2.19 *tracer, n*—A means of distinguishing one rope from another or one manufacturer from another by the use of yarns, tapes or other markers in a rope, either externally, internally or both. Also referred to as a marker.

(1)

3.2.19.1 *Discussion*—This marker can be different in color, size, or composition, or combination thereof, from that of the basic cordage. It can be found in the core or alongside a ply or strand.

3.2.20 *twist, n*—the number of turns about the axis applied to a fiber, yarn, strand or rope over a given length to combine the individual elements into a larger and stronger structure.

(1)

3.2.20.1 *Discussion*—The direction of twist in yarns is indicated by the capital letters S and Z. A 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.

3.2.21 *wale, n*—*in knitted fabrics*, a column of successive loops in the length direction of the fabric; *in woven fabrics*, one of a series of raised portions or ribs lying warp-wise in the fabric.

D123

3.2.22 *warp, n*—the yarn running lengthwise in a woven fabric.

D123

3.2.23 *weft (filling), n*—*in a woven fabric*, the yarn running from selvage to selvage at right angles to the warp.

D123

3.2.24 *woven fabric, n*—a structure produced when at least two sets of strands are interlaced, usually at right angles to each other, according to a predetermined pattern of interlacing, and such that at least one set is parallel to the axis along the lengthwise direction of the fabric.

D123

3.2.25 *yarn, n*—a generic term for a continuous strand of textile fibers, filaments, or material in a form suitable for knitting, weaving, or otherwise intertwining to form a textile fabric.

D123

4. Summary of Guide

4.1 Because of their general availability, fabrics and cordage are often encountered by forensic scientists who examine, identify, and compare these types of evidence. Structural details such as design, construction, and composition provide information that can assist the examiner in reaching a conclusion as to the possible end use or source of an item. Fabrics and cordage can also be examined for possible damage.

5. Significance and Use

5.1 The construction, composition, and color of textiles contain useful comparative characteristics for forensic examinations. Textiles are observed in a variety of constructions: woven, knit, nonwoven, or in combination. The range of colors in which textiles are offered in the marketplace is vast and constantly changing due to styles and seasons.

5.2 A complete characterization of the fabrics, including their construction, and other materials used in the assemblage of a textile (for example, sewing thread) is a critical component of a comprehensive forensic fabric or cordage examination.

6. Sample Handling

6.1 The general handling and tracking of samples should meet or exceed the requirements of Practice E1492 and Guide E1459.

6.2 In addition to written examination notes, items should be photographed to provide documentation of the original condition (for example, shape, position, layers or relation of one yarn to another), physical damage (for example, worn, cut, broken, frayed), and the presence of other evidence. Other evidence (for example, hair, blood, paint) that requires additional examination should be collected prior to textile analysis.

6.2.1 Photographs shall be taken if the entire sample is going to be consumed in analysis or if it is going to be completely deconstructed (for example, rope completely broken down into constituent parts).

6.3 A questioned material (for example, a piece of fabric, yarn, tuft of fibers) shall not be brought into contact with the known fabric from which it is suspected to have originated until a preliminary examination of the questioned specimen has been performed.

6.4 A sample to be used for composition testing should not be cut from ends of cordage or edges of fabric if there is a possibility of physically matching a questioned item to a known item. It is recommended that the known sample be collected away from the existing edge(s) and the location marked.

6.5 All data collected on questioned and known samples should be placed into, or referenced within, the specific case file.

6.6 The information contained on tags in textiles should be recorded, especially the registered number (RN) and the woolen products label number (WPL) when applicable. These refer to the manufacturer of the textile and can assist the examiner with tracking a particular textile or garment (3, 4). A

searchable database of RN and WPL numbers can be found on the Federal Trade Commission's website (5).

7. Analysis

7.1 Prior to conducting an initial analysis of the fibers comprising a fabric or cordage, the fabric or cordage should be examined for physical fits, pattern evidence and damage (for example, thermoplastic fusions, cut/tear marks). Adhesives or other material used in bonding fabrics, carpet backings, etc., should also be noted.

7.2 Physical Fit:

7.2.1 Physical fits should be considered if two or more pieces of fabric or cordage having cut or torn ends are compared.

7.2.2 If a physical fit is determined, it should be reported in a manner that will demonstrate that the two or more pieces of material were at one time a continuous piece of fabric or cordage. Document physical fits with descriptive notes to include photographs of the pertinent edges, the condition of corresponding threads (for example, a long thread directly across the break from a short thread), and their relative positions in the damaged area on the questioned and known pieces.

7.2.3 If a physical fit is not possible or none is found, comparison of the color, pattern, construction, and composition of the items in question should be undertaken as described below in 7.3 and 7.4.

7.3 Fabric:

7.3.1 A fabric examination is primarily a process of deconstructing the fabric by dissecting its constituent elements. Each of these elements can have a number of sub-elements, all of which shall be characterized. These elements include, but are not limited to, the following:

7.3.1.1 *Overall*—Construction (woven, knit, nonwoven) (6), number of yarns per inch in the warp and weft directions, color(s) and design, type of dyeing or printing, presence or appearance of sewing threads, buttons, decorations, selvage, defects.

7.3.1.2 *Yarn Construction*—Diameter, yarn twist, number of plies, direction of twist of each ply, staple or filament fibers, composition of yarn.

7.3.2 Fabric examinations of multiple samples can be carried out concurrently. If exclusionary differences are noted between the samples at any point during the examination, the samples are deemed different and no additional characterization is required.

7.3.3 A complete fabric examination includes the analysis and comparison of the constituent fibers using the appropriate microscopical, chemical, and instrumental techniques ((7, 8); Guides E2224, E2227, and E2228; and AATCC).

7.3.4 Fabric comparisons should be conducted between observed features or data collected using similar sample preparations, similar sample characteristics (for example, construction, number of yarns per inch in the warp and weft directions, color(s) and design, composition), and similar instrumental parameters, as appropriate.

7.3.5 The fabrics are compared and interpretations made based on the observation of all differences, or lack thereof, between the sets of data.

7.3.5.1 Fabric comparison is an approach where the fabric color, pattern, construction and composition are all considered in the evaluation as to whether exclusionary differences exist between compared samples.

7.3.5.2 When assessing differences between observed features or data, consider sample limitations (for example, small samples, dirty samples, damaged samples), instrumental limitations (for example, sampling size, limits of detection), and differences in sample preparation, sample characteristics and design, and instrumental parameters.

7.3.6 Possible reasons for differences include dissimilar sample characteristics (for example, construction, number of yarns per inch in the warp and weft directions, color(s) and design, composition), heterogeneity, contribution from extraneous materials, or origination from different source materials. Additional samples can provide supplemental data to assist in assessing such differences.

7.3.7 If suitable samples are available for examination, comparisons can provide information regarding the potential relationship between the sources of the samples.

7.3.7.1 When exclusionary differences are observed between compared fabric features, the sources of the samples are considered distinguishable by fabric comparison. Exclusionary differences in fabric comparisons: (1) are outside the variability in color, pattern, construction or composition of fabrics originating from the same source; and (2) cannot be explained by considerations such as sample heterogeneity, contamination, different sample conditions, or different sample histories.

7.3.7.2 When no exclusionary differences are observed between compared fabric features, the sources of the samples are considered indistinguishable by fabric comparison. Differences that are not considered exclusionary: (1) are within the variability in color, pattern, construction or composition of fabrics originating from the same source; or (2) can be explained by considerations such as sample heterogeneity, contamination, different sample conditions, or different sample histories.

7.4 Cordage:

7.4.1 A cordage examination is primarily a process of deconstructing the rope or cordage by dissecting its constituent elements. Examples of ways to dissect the rope or cord can be found in *The Cordage Directory* (4). Each of these elements can have a number of sub-elements, all of which shall be characterized. These elements include, but are not limited to, the following (9):

7.4.1.1 *Construction*—Diameter, colors, braided/plied, direction of twist, number of crowns or turns per inch, number of plies/strands/braids, presence and appearance of any core, coatings, or tracers.

7.4.1.2 *Plies/Strands/Braids*—Twisted or non-twisted, direction of twist for each, crowns or turns per inch for each, staple or filament fibers.

7.4.2 Cordage examinations of multiple samples can be carried out concurrently. If exclusionary differences are noted

between the samples at any point during the examination, the samples are deemed different and no additional characterization is required.

7.4.3 A complete cordage examination and comparison includes the analysis and comparison of the constituent fibers using the appropriate microscopical, chemical, and instrumental techniques ((7, 8); Guides E2224, E2227, and E2228; and AATCC).

7.4.4 Cordage comparisons should be conducted between observed features or data collected using similar sample preparations, similar sample characteristics (for example, number of crowns or turns per inch, direction of twist for each ply/strand/braid, color(s), composition), and similar instrumental parameters, as appropriate.

7.4.5 The cordage is compared and interpretations made based on the observation of all differences, or lack thereof, between the sets of data.

7.4.5.1 Cordage comparison is an approach where the cordage color, construction and composition are all considered in the evaluation as to whether exclusionary differences exist between compared samples.

7.4.5.2 When assessing differences between observed features or data, consider sample limitations (for example, small samples, dirty samples, damaged samples), instrumental limitations (for example, sampling size, limits of detection), and differences in sample preparation, sample characteristics and design, and instrumental parameters.

7.4.6 Possible reasons for differences include dissimilar sample characteristics (for example, number of crowns or turns per inch, direction of twist for each ply/strand/braid, color(s), composition), heterogeneity, contribution from extraneous materials, or origination from different source materials. Additional samples can provide supplemental data to assist in assessing such differences.

7.4.7 If suitable samples are available for examination, comparisons can provide information regarding the potential relationship between the sources of the samples.

7.4.7.1 When exclusionary differences are observed between compared cordage features, the sources of the samples are considered distinguishable by cordage comparison. Exclusionary differences in cordage comparisons: (1) are outside the variability in color, pattern, construction or composition of cordage originating from the same source; and (2) cannot be explained by considerations such as sample heterogeneity, contamination, different sample conditions, or different sample histories.

7.4.7.2 When no exclusionary differences are observed between compared cordage features, the sources of the samples are considered indistinguishable by cordage comparison. Differences that are not considered exclusionary: (1) are within the variability in color, construction and composition of cordage originating from the same source; or (2) can be explained by considerations such as sample heterogeneity, contamination, different sample conditions, or different sample histories.

7.5 Fabric Impressions:

7.5.1 Impressions made by textiles can provide valuable evidence. The weave or knit pattern of a textile impressed onto a surface or into blood, grease, etc., can be compared to the