This document sets forth background materials on the scientific research supporting examinations as conducted by the forensic laboratories at the Department of Justice. It also includes a discussion of significant policy matters. This document is provided to assist a public review and comment process of the related Proposed Uniform Language for Testimony and Reports (posted separately). It is not intended to, does not, and may not be relied upon to create any rights, substantive or procedural, enforceable by law by any party in any matter, civil or criminal, nor does it place any limitation on otherwise lawful investigative and litigative prerogatives of the Department of Justice.

SUPPORTING DOCUMENTATION FOR DEPARTMENT OF JUSTICE PROPOSED UNIFORM LANGUAGE FOR TESTIMONY AND REPORTS FOR THE FORENSIC TEXTILE FIBER DISCIPLINE

Background

The examination and comparison of textile fibers has been conducted for over a century. Early practices for textile identifications utilized compound light microscopy and chemical tests as the preferred methods.[1] Since that time, there have been numerous publications describing the examination, identification, and comparison of fibers utilizing various techniques.[2] Many of these techniques were developed and utilized by the textile industry[3] and adopted by the forensic science community. To date, the most common comparative methods employed for forensic purposes are comparison microscopy, polarized light microscopy, fluorescence microscopy, microspectrophotometry, and infrared spectroscopy.

A textile fiber is the basic element of textile materials such as apparel, carpeting, furniture, and cordage. A fiber can be natural (*e.g.*, cotton, wool, flax) or manufactured (*e.g.*, polyester, nylon, acrylic) and can be combined with other fibers in various ways to produce fabrics (*e.g.*,

[1] Matos, Louis J. (1915). The Identification of Textile Fibers. *Textiles*, pg. 16; Matos, Louis J. (1919). The Identification of Textile Fibers, Part 1. *Textiles*, 13-14; Matos, Louis J. (1919). The Identification of Textile Fibers, Part 2. *Textiles*, 16.

[2] American Society for Testing and Materials (1987): Standard Test Methods for Identification of Fibers in Textiles. ASTM D 276-87.; Scientific Working Group on Materials Analysis (SWGMAT), Forensic Fiber Examination Guidelines, *Forensic Science Communications*, Apr. 1999, vol. 1, no. 1; Robertson, J. and Grieve, M. (1999). Forensic Examination of Fibres, London: Taylor and Francis, Chapter 13; Houck, M.M. (2005). Forensic Fiber Examination and Analysis, Forensic Science Review, 17: 29, pp 30-49.; American Society for Testing and Materials (2008): Standard Guide for Forensic Analysis of Fibers by Infrared Spectroscopy. ASTM E 2224-02.

[3] Heyn, A.N.J. (1953). The Identification of Synthetic Fibers by Their Refractive Indices and Birefringence, *Textile Research Journal*, 23:246-251.; E.I. Du Pont de Nemours & Company. (1961): Identification of Fibers in Textile Materials. Technical Information Bulletin X-156.; The Textile Institute, Manchester (1985). Identification of Textile Materials, Manara Printing Services, London.; American Association of Textile Chemist and Colorists, AATCC Technical Manual, Research Triangle Park, NC; Mukhopadhyay, S. (2003). FTIR Spectroscopy – Principles and Applications. *Journal of the Textile Association*, 64 (4), 187-191.; Brady, Jr., R.F. (2003). Comprehensive Desk Reference of Polymer Characterization and Analysis: Polymer Characterization and Analysis, American Chemical Society and Oxford Univeristy Press, New York, NY.

knit, woven, non-woven).[4] These fabrics may lose fibers from their structure that can be transferred directly or indirectly from one location to another. The transfer and detection of fibers depends on the nature of the contact, the type of donor and recipient material, and the movement of the recipient following a transfer.[5]

Textile fibers recovered from an item can be analyzed to identify whether it is natural or manufactured. Natural fibers may be further examined to determine the type of fiber (*e.g.*, cotton, wool, or flax). Manufactured fibers may be further examined to identify the type of manufactured fiber (*e.g*., polyester, olefin, or acrylic) as well as the sub-group (*e.g.*, polyacrylonitrile methylacrylate or polypropylene). Furthermore, textile fibers may be examined to determine whether or not the questioned fiber is consistent with originating from a known source. Because textiles are mass produced, it cannot be concluded that a fiber originated from a particular source to the exclusion of all others. However, due to variations in the textile fiber population and the combination of techniques utilized for comparisons, one would not expect to encounter two fibers selected at random to exhibit the same microscopic characteristics and optical properties.[6]

Theory of Textile Fiber Examination

The examination of fibers relies on differences in microscopic characteristics and optical properties to classify and distinguish fibers. Studies have demonstrated that there is considerable variance in the fiber population, and that it would be unusual to encounter a fiber selected at random to be consistent with a particular source.[7] In a 2005 publication by Grieve et al., the authors stated the following:

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[4] Hatch, K.L. (1993). Textile Science. West Publishing Company, St. Paul, MN. Chapter 1.; Robertson, J. and Grieve, M. (1999); Forensic Examination of Fibres, London: Taylor and Francis, Chapters 1 and 2.

[5] Pounds,C.A.; Smalldon, K.W. (1975): The transfer of fibres between clothing materials during simulated contacts and their persistence during wear. Part I--fibre transference. *Journal of Forensic Science*, 15, 17-27; Pounds,C.A.; Smalldon, K.W. (1975): The transfer of fibres between clothing materials during simulated contacts and their persistence during wear. Part II--fibre persistence. *Journal of Forensic Science*, 15, 29-37; Pounds,.C.A.; Smalldon, K.W. (1975): The transfer of fibres between clothing materials during simulated contacts and their persistence during wear. Part III--a preliminary investigation of the mechanisms involved. *Journal of Forensic Science*, 15, 197-207; Robertson, J. and Grieve, M. (1999); Forensic Examination of Fibres, London: Taylor and Francis, Chapter 5.

[6] Scientific Working Group on Materials Analysis (SWGMAT), Forensic Fiber Examination Guidelines, *Forensic Science Communications*, Apr. 1999, vol. 1, no. 1, Chapter 1, Section 5.; Grieve, M.C., Biermann, T.W., and Schaub, K. (2005). The individuality of fibers used to provide forensic evidence – not all blue polyesters are the same, *Science and Justice*, 45: pp 13-28.; Robertson, J. and Grieve, M. (1999). Forensic Examination of Fibres, London: Taylor and Francis, Chapter 13; Houck, M.M. (2005). Forensic Fiber Examination and Analysis, Forensic Science Review, 17: 29, pp 30-49.

[7] Palmer, R., Hutchinson, W., Fryer, V. (2009). The discrimination of (non-denim) blue cotton. *Science & Justice*, 49, 12-18.; Palmer, Ray; Chinherende, Vongai (1996). A Targer Fiber Study Using Cinema and Car Seats as Recipient Items. *Journal of Forensic Sciences*, 41: 802-803. Grieve, M.C., Biermann, T.W., and Schaub, K. (2005) The individuality of fibers used to provide forensic evidence - not all blue polyesters are the same, *Science and Justice*, 45: 13-28.; Houck, Max (2003) Inter-comparison of unrelated fiber evidence, *Forensic Science International*, 135: 146-149. Jones, T. and Coyle, T. Synthetic flock fibres: a population and target fibre study. *Sci. Justice* 51(2), 68-71 (2010); Cook, R., and Wilson, C. The significance of finding extraneous fibers in contact cases. *Forensic Sci. Int.* 32 (4), 267-273 (1986); Jackson, G. and Cook, R. The significance of fibers found on car seats.

> Fibres used in forensic casework suffer from a disadvantage common to other forms of trace evidence – it is not possible to state with absolute certainty that they originate from a specific source. Target fibre studies, population studies and research on 'blocks of colour' have effectively demonstrated the polymorphism of textile fibres (particularly man-made ones) and have shown that when a fibre is believed to have a specific putative source, the chance that it was from a different source purely by coincidence is extremely remote.[8]

Similar statements have been made by other authors due to studies that demonstrated variance in the fiber population.[9] In a study by Houck, [10] colored fibers from twenty unrelated cases were compared using FBI Laboratory procedures. Of the 2083 compared fibers, 1979 (95%) were distinguished utilizing comparison microscopy and polarized light microscopy, while the remaining 5% were distinguished with fluorescence microscopy and microscopectrophotometry. According to Houck, none of the 2083 fibers "…selected at random exhibited the same microscopic characteristics and optical properties; phrased another way, no incidental positive associations were found."[11] In another study, Grieve *et al*.[12] compared 255 garments of the same fiber type and color (blue polyester) using comparison microscopy, polarized light microscopy, fluorescence microscopy, and microspectrophotometry. Blue polyester was chosen since it is one of the most common fiber types and colors in the fiber population. Of the 255 blue polyester samples, 9 pairs could not be distinguished, six of which were determined to be from the same brand name. Brand names from the remaining three pairs could not be determined.

Forensic Sci. Int. 32 (4), 275-281 (1986); Cook, R. and Salter A.-M. The significance of finding extraneous fibres on clothing. IAFS, Dusseldorf, 1993; Bruschweiler,W. and Grieve, M.C. A study on the random distribution of a red acrylic target fibre. *Sci Justice* 37 (2) 85-89 (1997); Cook, R., WebbSalter, M.T., and Marshall, L. The significance of fibres found in head hair. *Forensic Sci. Int.* 87 (2) 155-160 (1997); Kelly, E. and Griffin, R. A target fibre study on seats in public houses. *Sci. Justice* 38 (1) 39-44 (1998); Wiggins, K., Drummond, P., and Champod, T.H. A study in relation to the random distribution of four fibre types on clothing – (incorporating a review of previous target fibre studies). *Sci. Justice* 44 (3) 141-148 (2004); Coyle, T., Shaw, C., and Stevens, L. The evidential value of fibres used in 'Hi-Vis'work wear. https://www.researchgate.net/publication/259325803_The_evidential_value_of_fibres_used_in_Hi-Vis_workwear; Palmer, R., Burnett, E., Luff, N., Wagner, C., Stinga, G., Carney, C., and Sheridan, K. The prevalence of two 'commonly' encountered synthetic target fibres within a large urban environment. *Sci. Justice* 55, 103-106 (2015).

[8] Grieve, M.C., Biermann, T.W., and Schaub, K. (2005) The individuality of fibers used to provide forensic evidence - not all blue polyesters are the same, *Science and Justice*, 45: 13-28.

[9] Scientific Working Group on Materials Analysis (SWGMAT), Forensic Fiber Examination Guidelines, *Forensic Science Communications*, Apr. 1999, vol. 1, no. 1, Chapter 1, Section 5.5; Palmer, Ray; Chinherende, Vongai (1996). A Targer Fiber Study Using Cinema and Car Seats as Recipient Items. *Journal of Forensic Sciences*, 41: 802-803.; Wiggins, K; Drummond, P; and Champod, T Hicks (2004), A study in relation to the random distribution of four fibre types on clothing (incorporating a review of previous target fibre studies), *Science and Justice*, 44: 141-148.

[10] Houck, M. (2003) Inter-comparison of unrelated fiber evidence, *Forensic Science International*, 135: 146-149.

[11] *Id.* at 148-149.

[12] Grieve,M.C., Biermann, T.W., and Schaub, K. (2005) The individuality of fibers used to provide forensic evidence - not all blue polyesters are the same, *Science and Justice*, 45: 13-28.

One explanation for this variance is the variety of different fibers that are produced based on the textile industry's requirements for specific end-use and performance. The textile industry is comprised of thousands of fiber manufacturers and textile mills worldwide, and is constantly changing to satisfy demand and expected performance.[13] These manufacturers produce fibers of various type, size, and cross-sectional shape, and introduce other microscopic characteristics through the manufacturing and/or finishing process (*e.g*., delustering, voids, birefringence, mercerizing, texturing), typically for a desired result in the end-product.[14] Another contributing factor to variance in the fiber population is the dyeing process, in which color is added to either the fiber, yarn, fabric, or textile. There are thousands of dyes available for textiles, and the specific color requested by a consumer is usually achieved using a combination of dyes. Studies have shown that even different dye batches of the same product type can be distinguished.[15] Consumer use and wear of the textile product also accounts for some of the variance in the fiber population. Sunlight exposure, laundering, and other environmental effects can have an impact on the fiber's microscopic characteristics and optical properties.[16]

Ironically, the variance described above that makes fiber associations meaningful also complicates interpreting its significance. Studies have demonstrated that variation in the microscopic characteristics and optical properties of fibers provides meaningful comparisons.[17] However, due to the many variables involved, the specific number of sources that exhibit the same microscopic characteristics and optical properties as a questioned fiber cannot be determined.

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[13] World Directory of Manufactured Fiber Producers, Fiber Economics Bureau, Arlington, VA; Davison's Textile Blue Book, Davison Publishing Co., Inc, Concord, NC.

[14] Scientific Working Group on Materials Analysis (SWGMAT), Forensic Fiber Examination Guidelines, *Forensic Science Communications*, Apr. 1999, vol. 1, no. 1, Chapter 2.; Robertson, J. and Grieve, M. (1999). Forensic Examination of Fibres, London: Taylor and Francis, Chapter 7; Houck, M.M. (2005). Forensic Fiber Examination and Analysis, Forensic Science Review, 17: 29, pp 30-49. Hatch, K.L. (1993). Textile Science, West Publishing Company, St. Paul, MN.

[15] Robertson, J. and Grieve, M. (1999). Forensic Examination of Fibres, London: Taylor and Francis, Chapter 10; Palmer, R. (1995). A Survey of Dye Batch Variation, *Science and Justice*. 35, 59-64.; Wiggins, K., Cook, R. and Turner Y. (1988). Dye Batche Variation in Textile Fibers, Journal of forensic Sciences, 33:4, pp. 998-1007.; Wiggins, K. and Holmes, J.A. (2005). A further study of dye batch variation in textile and carpet fibres. *Science and Justice*, 45:2, 94-96.

[16] American Association of Textile Chemist and Colorists, AATCC Technical Manual, Research Triangle Park, N.C.; Was-Gubala, J. (2009). The kinetics of colour change in textiles and fibres treated with detergent solutions Part I – Colour perception and fluorescence microscopy analysis. *Science and Justice*, 49, 165-169. Was-Gubala, J., Grzesiak, E. (2010). The kinetics of colour change in textiles and fibres treated with detergent solutions Part II – Spectrophotometric measurements. *Science and Justice*, 50, 55-58.

[17] Grieve, M.C., Biermann, T.W., and Schaub, K. (2005) The individuality of fibers used to provide forensic evidence - not all blue polyesters are the same, *Science and Justice*, 45: 13-28.; Houck, Max (2003) Inter-comparison of unrelated fiber evidence, *Forensic Science International*, 135: 146-149.; Palmer, R., Hutchinson, W., Fryer, V. (2009). The discrimination of (non-denim) blue cotton. *Science & Justice*, 49, 12-18.; Palmer , Ray; Chinherende, Vongai (1996). A Targer Fiber Study Using Cinema and Car Seats as Recipient Items. *Journal of Forensic Sciences*, 41: 802-803.

Textile Fiber Comparison Process

There are different methodologies and processes for conducting a fiber examination. The Department shares information regarding some appropriate processes below. The Department does not suggest that the processes outlined here are the only valid or appropriate processes.

The general procedure for textile fiber comparisons begins with a side-by-side examination of the microscopic characteristics. A comparison microscope (approximately 50x- to 600x-magnification) is required to visualize and compare the microscopic characteristics. For natural fibers, characteristics such as color, surface color, color variation, shape, and diameter are compared. Additional characteristics such as the presence and size of voids, delustrant, manufacturing striations, pigment, and inclusions may be observed when comparing manufactured fibers (Figure 1).[18]

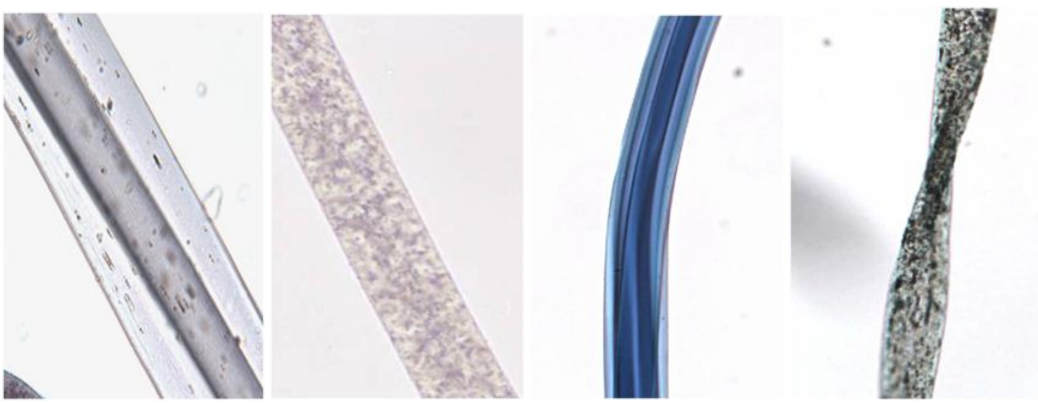

Figure 1: Images of manufactured fibers.

If fibers are indistinguishable utilizing comparison microscopy, they are further examined with polarized light microscopy. For natural and manufactured fibers, polarized light microscopy can determine if the fibers display different colors when viewed at different orientations to polarized light.[19] For manufactured fibers, characteristics such as the relative refractive index[20] and estimated birefringence[21] are also compared. The properties observed

[18] Scientific Working Group on Materials Analysis (SWGMAT), Forensic Fiber Examination Guidelines, *Forensic Science Communications*, Apr. 1999, vol. 1, no. 1, Chapter 2.; Robertson, J. and Grieve, M. (1999). Forensic Examination of Fibres, London: Taylor and Francis, Chapter 7; Houck, M.M. (2005). Forensic Fiber Examination and Analysis, Forensic Science Review, 17: 29, pp 30-49.

[19] Polarized light is light that has been altered so that vibrations occur in a single plane. A polarized light microscope is equipped with filters capable of producing polarized light.

[20] Refractive index is the ratio of the speed of light in a material compared to the speed of light in a vacuum. Textile fibers have two refractive indices, one parallel ($n_{\parallel}$) to the fiber axis and one perpendicular ($n_{\perp}$). These refractive indices are measured relative to the mounting medium the fibers are in when prepared on glass microscope slides (*e.g.*, Permount®).

depend on the type of fiber (*e.g*, polyester, nylon) and the orientation of the molecules along the fiber's axis.[22]

Fibers that are indistinguishable utilizing comparison microscopy and polarized light microscopy are further compared using fluorescence microscopy. Fluorescence is emission of light at a longer wavelength following excitation by light of shorter wavelength. With fluorescence microscopy, fibers are illuminated at four distinct wavelength ranges so that the color and intensity of the fiber's fluorescence can be documented and compared (Figure 2). Dyes, optical brighteners and other additives can contribute towards the observed fluorescence.[23]

Figure 2: Images of the same set of fibers viewed with A) transmitted light microscopy; B) fluorescence microscopy using 450nm-490nm excitation; C) fluorescence microscopy using 510nm – 560nm excitation.

If colored fibers cannot be distinguished utilizing comparison microscopy, polarized light microscopy, and fluorescence microscopy, they are further examined and compared with microspectrophotometry. Microspectrophometry (MSP) is used to compare the fiber's absorption of ultraviolet and/or visible light. This method provides an instrumental means for analyzing the fiber color, and can distinguish fibers that have the same visual color using comparison microscopy.[24]

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[21] Birefringence is the difference between the fiber's refractive indices ($n_{\parallel} - n_{\perp}$). An estimated value of the birefringence can be calculated using a polarized light microscope that is equipped with two polarizing filters.

[22] Rochow, T.G. and Tucker, P.A. (1994). Introduction to Microscopy by Means of Light, Electrons, X Rays, or Acoustics, Plenum Publishing Corporation, New York, NY.; Scientific Working Group on Materials Analysis (SWGMAT), Forensic Fiber Examination Guidelines, *Forensic Science Communications*, Apr. 1999, vol. 1, no. 1, Chapter 2.; Robertson, J. and Grieve, M. (1999). Forensic Examination of Fibres, London: Taylor and Francis, Chapter 7; Houck, M.M. (2005). Forensic Fiber Examination and Analysis, Forensic Science Review, 17: 29, pp 30-49.

[23] Scientific Working Group on Materials Analysis (SWGMAT), Forensic Fiber Examination Guidelines, *Forensic Science Communications*, Apr. 1999, vol. 1, no. 1, Chapter 2.; Robertson, J. and Grieve, M. (1999). Forensic Examination of Fibres, London: Taylor and Francis, Chapter 7.

[24] Scientific Working Group on Materials Analysis (SWGMAT), Forensic Fiber Examination Guidelines, *Forensic Science Communications*, Apr. 1999, vol. 1, no. 1, Chapter 3.; Robertson, J. and Grieve, M. (1999). Forensic Examination of Fibres, London: Taylor and Francis, Chapter 10.; Houck, M., Walbridge-Jones, S., (2009). Forensic Identification of textile fibers: Chapter 9 – Microspectrophotometry for textile fiber color measurement. The Textile Institute, Woodhead Publishing Limited, Cambridge, England.

If manufactured fibers are not distinguished using the methods above, fibers will be examined using infrared spectroscopy. Infrared spectroscopy detects the fiber's absorption of infrared radiation. While the technique is typically not as discriminating as the techniques listed above, it provides additional information about the chemical structure of the fiber and allows for the characterization and comparison of polymer composition. Natural fibers are not examined using infrared spectroscopy since the technique provides no additional compositional information.[25]

If the fibers are indistinguishable utilizing the applicable techniques described above, it can be concluded that the fibers are consistent with originating from the same item, or another item comprised of fibers that exhibit the same microscopic characteristics and optical properties. If the fibers can be distinguished using any of the techniques described above, it can be concluded that the fibers are not consistent with originating from the same item.

Policy Considerations

In 2006, Congress authorized the National Academy of Sciences (NAS) to conduct a study on forensic science which culminated in a 2009 report.[26] The NAS report of 2009 reiterated the basis, benefit, and limitations for the long established forensic discipline of fiber analysis:

> Fibers associated with a crime—including synthetic fibers such as nylon, polyester and acrylic as well as botanical fibers such as ramie or jute, which are common in ropes or twines—can be examined microscopically in the same way as hairs, and with the same limitations. However, fibers also can be analyzed using the tools of analytical chemistry, which provide a more solid scientific footing than that underlying morphological examination. In some cases, clothing and carpets have been subjected to relatively distinctive environmental conditions (*e.g.*, sunlight exposure or laundering agents) that impart characteristics that can distinguish particular items from others from the same manufacturing lot. Fiber examiners agree, however, that none of these characteristics is suitable for individualizing fibers (associating a fiber from a crime scene with one, and only one, source) and that fiber evidence can be used only to associate a given fiber with a class of fibers.[27]

The NAS report highlighted several areas for improvement within the generally accepted scientific standards of fiber analysis. One area it identified was that there "have been no studies to inform judgments about whether environmentally related changes discerned in particular

[25] Scientific Working Group on Materials Analysis (SWGMAT), Forensic Fiber Examination Guidelines, *Forensic Science Communications*, Apr. 1999, vol. 1, no. 1, Chapter 6.; Robertson, J. and Grieve, M. (1999). Forensic Examination of Fibres, London: Taylor and Francis, Chapter 8.

[26] ----. (2009). National Research Council. Strengthening Forensic Science in the United States: A Path Forward (Summary and Friction Ridge Analysis section from Chapter 5). National Academy Press: Washington, D.C. (http://www.nap.edu/catalog/12589.html).

[27] NAS report at 161, citing, *e.g.*, Breese, R.R. (1987) Evaluation of textile fiber evidence: A review. *J. For Sci.* 32 (2), 510-11; SWGMAT. (1999) Introduction to forensic fiber examination. *For. Sci. Comm.* 1 (1), available at www.fbi.gov/hq/lab/fsc/backissu/april1999/houcktoc.htm.

fibers are distinctive enough to reliably individualize their source"[28]. While it has been established that the environment can have an impact on the microscopic characteristics and optical properties of fibers,[29] it is doubtful that these changes would ever allow individualization to a single source.

A second area highlighted in the NAS report was that there "have been no studies that characterize either reliability or error rates in the procedures."[30] While it is true that no studies have identified "error rates in the procedures" or studies to show the statistical probability of a coincidental fiber association, numerous studies (referenced previously) have been published demonstrating the reliability of fiber examination procedures.

The NAS report also made the following assertion:

> A group of experienced paint [*sic*] examiners, the Fiber Subgroup of the Scientific Working Group on Materials Analysis (SWGMAT), has produced guidelines, but no set standards, for the number and quality of characteristics that must correspond in order to conclude that two fibers came from the same manufacturing batch. There have been no studies of fibers (*e.g.*, the variability of their characteristics during and after manufacturing) on which to base such a threshold.[31]

SWGMAT has indeed produced guidelines covering the forensic examination of fibers. However, fiber examiners have long realized that associating fibers to a given dye (manufacturing) batch is a goal that cannot be reached. There have been a few studies demonstrating the ability to sometimes distinguish between different dye batches, however, fiber examiners cannot conclude that fibers came from the same batch since different batches cannot always be distinguished.[32]

The NAS report addressed the fact that measurement uncertainties have not been developed for the various analytical procedures utilized by fiber examiners: "[b]ecause the analysis of fibers is made largely through well-characterized methods of chemistry, it would be possible in principle to develop an understanding of the uncertainties associated with those analyses."[33]

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[28] NAS report at 163.

[29] American Association of Textile Chemist and Colorists, AATCC Technical Manual, Research Triangle Park, N.C.; Was-Gubala, J. (2009). The kinetics of colour change in textiles and fibres treated with detergent solutions Part I – Colour perception and fluorescence microscopy analysis. *Science and Justice,* 49, 165-169. Was-Gubala, J., Grzesiak, E. (2010). The kinetics of colour change in textiles and fibres treated with detergent solutions Part II – Spectrophotometric measurements. *Science and Justice,* 50, 55-58.

[30] NAS report at 163.

[31] NAS report at 162-163.

[32] Palmer, R. (1995). A Survey of Dye Batch Variation, *Science and Justice*. 35, 59-64.; Wiggins, K., Cook, R. and Turner Y. (1988). Dye Batch Variation in Textile Fibers, Journal of forensic Sciences, 33:4, pp. 998-1007; Wiggins, K. and Holmes, J.A. (2005). A further study of dye batch variation in textile and carpet fibres. *Science and Justice*, 45:2, 94-96.

[33] NAS report at 163, citing to Breese, R.R. (1987) Evaluation of textile fiber evidence: A review. *J. For Sci.* 32 (2), 510-11.

Finally, the NAS report summarized facts that are widely accepted in the forensic science community, that "…a 'match' means only that the fibers could have come from the same type of garment, carpet, or furniture; it can provide class evidence…"[34], and that "[f]iber analyses are reproducible across laboratories because there are standardized procedures for such analyses."[35]

[34] NAS report at 163.

[35] *Id.*