1. SCOPE

Usually, the forensic fiber examiner is requested to compare questioned and known (Q and K) fiber samples based on their physical and chemical compositions. In conducting those comparisons, the forensic fiber examiner's goal is to assess the significance of any differences observed. The absence of any significant differences between the known and questioned samples suggests that the fibers could have had a common source of origin.

Besides a Q vs. K comparison, the examiner may also be requested to analyze a questioned fiber and attempt to determine the possible source(s) of origin for that sample.

The physical, optical and chemical properties of known and/or questioned fibers may include: Physical - color, cross-section, diameter, delusterant, surface characteristics: Optical - birefringence, refractive index (indices), sign of elongation, and extinction characteristics: Chemical – microsolubility/microchemical tests, FTIR and PGC-MS.

Known and questioned fiber(s) may be compared and the properties noted. Examinations and analyses may include polarized light microscopy, comparison microscopy, solubility/micro-chemical tests, microspectrophotometry, FTIR, and PGC or PGC-MS. The order of these exams and any additional testing is left to the discretion of the examiner and based upon the evidence at hand. In bombing cases, fiber recovery from the device in question is of paramount importance. Generally, environmental (scene) fibers will be encountered in all such cases and have little to no probative value in the case. Fibers recovered from protected (pristine) areas of the device (i.e. under or in between multilayered tape) may be significant since their deposition could have been affected at the time the device was manufactured.

II. REFERENCES

1. Scientific Working Group for Materials Analysis, Forensic Fiber Examination Guidelines, June, 1999.
2. ASTM Standard E 1459-92 Standard Guide for Physical Evidence Labeling and Related Documentation.
3. ASTM Standard E1492-92 Standard Practice for Receiving, Documenting, Storing and retrieving Evidence in a Forensic Science Laboratory
4. Scientific Working Group for Materials Analysis, Fiber Guidelines, June, 1999.

5. Gaudette, B.D. In Forensic Science Handbook; Saferstein, R., Ed.; Prentice Hall: Englewood Cliffs, N.J., 1988; Vol. II, Chapter 5.

6. Scientific Working Group for Materials Analysis, Forensic Fiber Examination Guidelines, June 1999.

7. Nielsen, Mark, R., "Common Natural Fibers" from a handout given

    a. at a paper presentation at the Midwestern Association of Forensic

    b. Scientists meeting, October 1998.

8. "Fiber Analysis of Paper and Paperboard" T401 om-88 Official standard from the Technical Association of the Pulp and Paper Industry (TAPPI), 1988.

9. "Identification of North American Commercial Pulpwoods and Pulp Fibers" Strelis and Kennedy, University of Toronto Press, 1967

10. Palenik, Sameul, J., Microscopical Examination of Fibres. In: Forensic Examination of Fibres. 2nd ed., James Robertson and Michael Grieve, Philadelphia, 1999.

11. Petraco, N. and Kubic, T. Color Atlas and Manual of Microscopy for Criminalists, Chemists, and Conservators. CRC Press, Boca Raton, 2004.

Validation

The techniques described below for fiber examination are well known and scientifically accepted in the forensic science community and in private industry. Relevant examples of related literature can be found in Section II (References).

III. SAFETY CONSIDERATIONS

1. The examiner should follow all the biohazard procedures and use universal safety precautions.

2. Precautions need to be taken whenever working with chemicals which could pose potential health hazards.

IV. APPARATUS / REAGENTS

1. Sticky sided collecting materials such as tape or Post-it Notes
2. Forceps
3. Containers such as glassine envelopes, plastic bags or vials
4. Illuminated Magnifier
5. UV Light or Alternative Light Source
6. Transparent securing substrates such as slides or sheet protectors
7. Glass microscope slides
8. Glass cover-slips
9. Mounting medium
10. Solvents/stains/micro-chemical reagents
11. Stereomicroscope, Polarized Light microscope or Comparison microscope
12. Microscope with Fluorescence attachments
13. FTIR
14. Microspectrophotometer
15. Pyrolysis GC or PGC-MS
16. Miscellaneous analytical instrumentation
17. High Temperature silicone oil
18. Hot-Stage apparatus

V. PROCEDURES

A. RECOVERY OF FIBERS

Purpose:

Items of evidence are examined for foreign fibers that may be associated with a known source. Document the condition of the submitted items (i.e. intact, buttons missing, apparent rips or tears, etc.) and include a brief description of any design, logos or lettering present on evidence. Descriptions may include garment or textile label information such as fiber content, brand or manufacturer, manufacturer's numbers such as the RN# or WPL# and the size.

Summary:

Generally speaking, submitting the article or articles of evidence to the laboratory for the examiner to process is the best approach to the recovery of fibers. There are instances where this is not practical or possible, such as recovering fibers from wall-to-wall carpeting, a large piece of furniture, or a vehicle. In these instances, the recovery may be accomplished at the scene with the aid of an alternative light source, if available, and the recovered fibers submitted for examination.

Usually the order of preference for the recovery of fibers is manual removal followed by taping. Gentle scraping may be necessary in certain instances. Vacuuming can also be used to collect debris, however it is not preferred because the debris recovered often represents far more than recent fiber transfers.

Multi-layered tape recovered directly from devices should be separated layer by layer and examined for any fibers or other evidence that could have originated from the environment in which the explosive device was manufactured. Latent print examinations may be performed before and/or after the tape is separated; therefore, the examiner must handle the recovered tape with this in mind. Fibers of interest found in the pristine area of the tape are removed with clean forceps.

Minimum Standards and Controls:

1. If possible, the victim's evidence and suspect's evidence should be examined in separate rooms. If this is not possible, then the separation of victim and suspect evidence in time and/or space will be necessary. At no time should questioned items and known items be open at the same time in the same area.

2. The examiner must clean the examination area and change the examination paper between processing victim and suspect or scene exhibits at a minimum.

3. The examiner must change gloves and clean their tools between examining the evidence from the victim and the evidence from the suspect. Use separate laboratory coats during the collection of the known and questioned items.

4. The examiner should follow all the biohazard procedures and use universal safety precautions.

Sampling/Sample Selection:

Many items such as tapes or garments will have too many fibers present on them to collect every fiber. Care should be taken to select a representative sample of each visually different fiber type for further analysis.

Analytical Procedure for Recovery of Fibers:

1. Clean the examination area. Spread a clean piece of butcher or Kraft paper out on the examination surface.

2. Examine each item of evidence visually or with the aid of an illuminated magnifier, UV light or other alternative light source(s).

3. If the item being examined contains fibers that are readily visible, collect them. As fibers are collected, they should be secured and/or preserved in an appropriate manner.

4. Care should be taken to avoid the loss of any fibers, especially when repositioning bulky items.

5. Adhesive tapes and/or other adhesive devices (e.g. “Post-it Notes”, lint rollers, etc) may be used to recover fibers. The adhesive surface is placed on the item being examined and then pulled away.

6. Other collection methods may be used including vacuuming and scraping. If scraping is necessary, the item to be examined is suspended above the examination surface and very gently scraped with a spatula. Scraping in a downward direction allows surface fibers to fall onto the examination surface for collection. If vacuuming is used then separate filters should be used for each item/area.

7. When recovering fibers from tape present on submitted items, fibers should be considered valuable evidence only if they are recovered from protected surfaces (such as between layers of tape, or between the tape and the item that the tape is adhering to). While some fibers of value may be found on exposed areas of the tape, the fact that environmental (scene) fibers having no probative value may also be present on these areas should be taken into consideration. Latent print considerations of these tape pieces are paramount as well as other trace evidence (see “Tape Protocol”). Multiple layers of tape should be separated layer by layer for examination. Remove any fibers from the freshly exposed adhesive area(s) and document. The exposed tape adhesive may be placed on a clean sheet of plastic, glass or a screen for transfer to latent prints.

B. FIBER IDENTIFICATION

Purpose:

When no known fibers/fabrics are submitted for comparison purposes, the unknown fibers may be characterized and identified as to their generic class/sub-class to identify a possible source of the fibers which may provide investigative leads. In these instances, fibers may be identified through stereomicroscopy and polarized light microscopy only (although other instrumental methods may be used at the discretion of the analyst). Other analytical methods are employed when comparisons are to be conducted between known and unknown fibers.

Minimum Standards and Controls:

1. A reference collection of fibers may be useful to the examiner when identifying the generic class and/or subgeneric classes.

2. Reference information including (but not limited to) a collection of FTIR spectra, tables of physical and optical properties of known fibers is desirable.

Sampling/Sample Selection:

Fibers should first be examined using a stereomicroscope. The different physical characteristics should be observed. Fibers may be mounted on glass slides as deemed necessary. When numerous fibers are present in a questioned sample, the examiner will evaluate the fibers on a case by case basis and should attempt to mount up a representative sample of fibers that display the range of variation seen within the sample.

If a number of questioned fibers are recovered which are to be identified, these shall be characterized using the polarizing light microscope. If it is concluded that all the questioned fibers are consistent in fiber type, color, diameter, cross-sectional shape and optical properties to one another, then they can be considered a homogeneous group and additional analysis (e.g. FTIR, MSP) can then be performed on a select few of the questioned fibers. In these instances, results of the additional examinations can be used to represent the group of microscopically consistent fibers as a whole.

Analytical Procedure for Fiber Identification:

1. Observe and record the physical and optical properties of the fibers utilizing polarized light microscope (PLM). Classify the fiber type based on the characteristics noted if necessary.
2. When necessary, obtain FTIR spectra of the fiber and compare the spectrum obtained with reference spectra of fibers.
3. Solubility/staining/microchemical tests may be conducted.
4. If desired, a cross-section of the fiber may be made using appropriate techniques.
5. Other analytical techniques commonly used for the comparison of fibers may be used as deemed necessary.

C. COMPARISON OF QUESTIONED AND KNOWN FIBERS

Purpose:

In some cases, a known sample of fibers/fabric is identified and submitted. In these instances, questioned fibers which have been recovered on probative items can be compared to the fibers comprising the known item to determine if they could have originated from the known source.

Minimum Standards and Controls:

1. A comparison microscope and/or polarized light microscope should be used when comparing known and questioned fibers.
2. A suitable known fiber sample should be used to obtain the best and most reliable results in a fiber comparison.

Sampling / Sample Selection:

Known Fibers: When an entire known sample is submitted and is either a textile and/or a sample of fibers selected by an investigator/crime scene responder, the scientist can assume homogeneity (although different fiber types may be present in the known sample, it can still be assumed they came from the same source). Knowledge of the manufacturing process for the types of fiber evidence encountered in casework as well as a visual examination of the fibers present in the sample aids in choosing an appropriate representative known sample. A known sample should consist of enough fibers to represent the different fiber types/colors present in a particular textile/fabric.

Questioned Fibers: If a number of questioned fibers are recovered which are to be compared with the known fibers, these shall be characterized and compared using the polarizing light microscope. If it is concluded that all the questioned fibers are consistent in fiber type, color, diameter, cross-sectional shape and optical properties with one another, they can be considered a homogeneous group and additional analysis (e.g. FTIR, MSP) can then be performed on a select few of the questioned fibers. In these instances, results of the additional examinations can be used to represent the group of microscopically consistent questioned fibers as a whole.

Analytical Procedures for the Comparison of Questioned and Known Fibers:

1. When comparing fibers, the same analytical techniques should be performed in the same manner on both the known and questioned fibers.

2. At any time during the fiber examination scheme, if any significant differences are detected between the questioned and known fibers, a conclusion can be made that the fibers do not have a mutual origin and no further examination/comparison is necessary.

3. Generally, when sample size is limited, destructive testing is performed after all non-destructive testing is complete.

4. Comparison microscopy, polarized light microscopy, and/or fluorescence microscopy should be conducted with all fiber comparisons.

5. FTIR should be conducted when man-made (synthetic) fibers are to be compared (Regenerated cellulosic fibers may be analyzed at the examiners discretion). Compare the known and questioned spectra. Any major discrepancy between the two is reason for elimination.

6. MSP (or TLC) should be considered when colored fibers are to be compared (although very light fibers or very dark fibers may not produce useful results). With MSP it may be necessary to obtain several spectra along the length of a given fiber or from several different fibers of the same color to determine the reproducibility of the spectra. Any unexplained discrepancy between the known and questioned fibers is reason for elimination.

7. PGC chromatograms or PGC-MS total ion chromatograms may be conducted and the results compared between the questioned and known fibers. Any major discrepancy between the two is reason for elimination.

D. OTHER ANALYTICAL TECHNIQUES (HOT STAGE MICROSCOPY)

Purpose:

There may be instances were observing the melting point behavior of thermoplastic fibers under the microscope may provide valuable information for fiber identification, sub-classification and/or comparison.

Minimum Standards and Controls for Hot Stage Microscopy:

The hot stage apparatus must be capable of reaching at least 300°C and should fit the stage of the polarizing microscope. A clear image of the fiber should be visible by transmitted light at a magnification of at least 100X. The temperature of the hot stage should be able to be raised by as little as 4°C per minute, or less. The hot stage should be performance checked and adjusted with melting point standards within 30 days of running the casework samples if using for fiber identification or sub-classification.

Analytical Procedures for Hot Stage Microscopy:

1. Fibers may be mounted in air or in high temperature silicon oil. Only a small length of fiber is necessary.
2. The following observations are made through the polarized light microscope. The melting point range (when the fiber starts to melt and has completely melted) should be recorded.
3. Multiple measurements should be made when determining fiber identification, sub-classification and/or comparison. The number of measurements taken is left to the discretion of the examiner and may be based on sample size.
4. Thermal microscopy is a destructive technique; all non-destructive techniques should be performed before destructive techniques.

E. NATURAL FIBERS

Purpose:

To distinguish between the different types of natural fibers used in fabric and cordage

Minimum Standards and Controls for Natural Fiber Examinations:

A reference collection is useful when examining natural fibers. When chemicals or stains are used, a reference fiber should be examined side by side with the questioned and known fibers, and subjected to

the same conditions and stains to assure the chemicals/stains are working properly. Results of these tests should be documented in the case record.

Analytical Procedures for Natural Fiber Examinations:

1. Fibers should be first examined using a stereomicroscope. The different physical characteristics should be noted.
2. Observe the physical and optical properties of the fibers utilizing the polarized light microscope (PLM). Note if the fiber comes to full extinction, shows little extinction, has undulating extinction or has no extinction. With regards to plant fibers, it may be necessary to separate the bundles of fibers into ultimates. There are many different procedures for macerating the bundles. Note any microscopical observations, for example: size and shape of the lumen, presence of nodes, presence of spirals, presence of scales, etc.
3. The Herzog Test may be used to classify/identify the various types of natural fibers. Examine the fibers using a full wave plate (analyzer engaged) to determine the twist of the fiber and note whether the reaction is weak or strong. Dispersion staining and dry twist tests may also be useful in distinguishing between the various types of natural fibers.
4. A number of stains (i.e.: Graff's C Stain, Herzberg Stain) are available and may be used to further distinguish the natural fibers.

VI. QUALITY ASSURANCE/ QUALITY CONTROLS

Through proper training, competency testing, and proficiency testing of fiber examiners as well as through the use of high quality microscopes and equipment which are appropriately cleaned, maintained, and quality checked (e.g. calibrated, performance checked) the quality of this method is assured.

Because fibers are mass produced, a questioned fiber can never be positively identified back to a specific source; therefore, the use of error rates is not applicable.