

FIBER ANALYSIS

1. General appearance of question fibers or known fiber samples should be observed under the stereomicroscope (low power magnification) before mounting on slides so the following characteristics can be seen and noted:
 - color (variation and dull vs. bright)
 - matter adhering to the fibers (e.g. paint, soil, blood, adhesives)
 - texture (crimping, twist, loops)
2. Observations and comparisons after mounting on slides (longitudinal and cross-sectional views) should include the following:
 - variation in fiber type
 - size (diameter or thickness)
 - shape (e.g. round, trilobal, polygonal, crenulated, etc.)
 - modification ratios
 - uniformity
 - surface texture (e.g. smooth, pitted, rough, scales, etc.)
 - interstructure (e.g. lumen, holes, voids, etc.)
 - markings (type, direction)
 - delustrant (particle size, shape, concentration, and distribution)
 - dyes or coloration (shades, intensity of colors, distribution, pigmentation)
 - fiber or yarn processing
 - optical properties (refractive indices, sign of elongation, birefringence, pleochroic effect)
 - fluorescence (attributed to polymer, additives, dyes, or finishes)
3. Qualitative and quantitative color analysis and comparison can be performed on colored (dyed) fibers using the Nanometrics microspectrophotometer.
4. Qualitative analysis and comparison can be performed on the question and known samples using the FTIR spectrometer.
5. If the amount of question and known fiber samples allow, the following tests can be performed:
6. Make a preliminary determination of the source (e.g. carpet)

based on the characteristics observed.

YARN ANALYSIS

1. General appearance of question yarns and known yarns should be observed under the stereomicroscope (low power magnification) before the yarn is broken down to determine the fiber composition so that the following characteristics can be noted:

- a. Matter adhering to the yarn.

- Remove hairs and fiber foreign to the composition of the yarn.
- Remove particles (paint, soil, glass, metal).
- Note stains (e.g. oil, blood, paint).
- Note attached adhesives or bonding materials.
- Note coatings (e.g. starch, plastic, resins).

- b. Size (e.g. diameter and length).

- c. Overall coloring.

- Shades and intensity of color or coloring.
- Distribution of dyes (e.g. solid color, piece dyed, printed).
- Stains due to soiling, bleach or light damage.

- d. Shape (as received).

- Signs of having once been woven or knitted.
- Signs of having come from a "pile fabric" (pile may be cut and/or uncut, looped or curled). In a "V" weave, short "V"-shaped yarns are found, often held in place with a rubber coating. In a "W" weave, short "W"-shaped yarns are found. The length of each "V"-shaped or "W"-shaped yarn will be consistent.

- e. Determine type or types of yarn present in the question and known specimens.

- Spun (staple) or multifilament (or monofilament).
- Bulky or tightly twisted.
- Ordinary, stretch, texturized or novelty.

f. Determine how the yarn was constructed.

- If the yarn is not "twisted", count the number of filaments.
- If the yarn is single "ply" and twisted, determine the direction of the twist (S or Z) and count the number of "filaments".
- If the yarn has two or more "plies" and is twisted together, count the number of "plies" and determine the direction that these "plies" are twisted together.

Count the number of "strands" within each "ply" and determine the direction that the "strands" are twisted together. Count the number of "yarns" within each "strand" and determine the direction that the yarns are twisted together. Count the number of filaments within each yarn (if multifilament) and determine the direction that the filaments are twisted together.

NOTE: The terms "ply", "strand", and "yarn" may be used interchangeable until the final unit is a single yarn (one ply) composed of fibers or filaments.

- If the yarn is a "stretch yarn", determine if one or more plies are wrapped or twisted over a "core" and note any texturization.

2. Determine the fiber composition of each yarn.

- a. All are one type of fiber (multiple colors, lustrous, dull, or semi-dull).
- b. Blend of two or more types of fibers within each "ply".
- c. Combination of one "ply" containing one type of fiber (or blend of fibers) and another "ply" containing a different type of fiber (or blend of fibers).
- d. Identify and compare all fiber types present (See Fiber Analysis section).

FABRIC ANALYSIS

1. General appearance of question fabrics and known fabrics should be observed under the stereomicroscope before the fabric is broken down to determine the yarn construction and the fiber composition.

a. Matter adhering to the fabric.

- i. Remove any loose hairs, foreign fibers, particles, etc.
- ii. Note stains (e.g. blood, paint).
- iii. Note attached materials (e.g. adhesive, bonding material).

b. General size, shape, and condition.

- i. One or more layers of fabric, or yarn from a second layer.
- ii. Cut, torn, crushed or burned edges or surface.
- iii. Distortion (after photographing or diagraming the "as is" condition of both sides of the fabric specimen, gently align fabric into its original shape).

c. Type and color of fabric.

i. If the fabric is woven.

- One or more types of warp yarns vs. One or more types of filling yarns (size, color, and construction).
- Type of weave (plain, twill, etc.).
- Weave variations or (i.e. 2/2 plain basket weave).
- Yarn counts (warp/centimeter or inch and fillings/centimeter or inch).

ii. If the fabric is knitted.

- Type of knit (plain, tricot, double, etc.).
- One or more types of yarn (size, color, and construction).
- Loop counts (courses/centimeter or inch and wales/centimeter or inch).

iii. If the fabric is nonwoven.

- Determine the type (e.g. felted, bonded, etc.).
- Note construction characteristics (e.g. heat set, mechanical, resin bonded).

iv. Design and pattern.

- Determine the type (e.g. corduroy, tufted, cut pile).
- Color patterns (e.g. individual colored yarns or colors printed on fabrics).
- Patterns due to different types and/or sizes of yarns of the same color.

v. Determine yarn construction and fiber composition (See Fiber Analysis and Yarn Analysis sections) without disrupting the shape or design of the fabric.

d. Points which may identify a question piece of fabric with a particular item (e.g. trousers, jacket).

- i. Portions of seams, pockets, cuffs, collars, selvage edges, etc.
- ii. Portions of buttons, buttonholes, hooks, snaps, etc.
- iii. Sewing thread and stitching holes.
- iv. Portions of linings and interlinings.
- v. Portions of "trim", labels, etc.

2. When known and question fabric is available, locate "good points of identification".

- a. Unusual contours.
- b. Extra long yarns extending from the edges.
- c. Short yarns ending within the piece of fabric.
- d. Heavy (thick) and thin yarns.
- e. Different types and colors of yarn.
- f. Design and color patterns.
- g. Stitched areas.
- h. Stained or damaged areas on the fabric.
- i. Selvages, the construction can vary in width, warps/inch, edges, and yarn and fiber comparison.

3. Stitched items (e.g. garments, gloves, bags, bedding).
 - a. Homemade or factory manufactured.
 - b. Stitched by machine or by hand.
 - c. Sew thread (color and type of top and bobbin threads used throughout item, evenness of stitch, knots).
4. Charred and/or burned fabric.
 - a. Handle carefully.
 - b. It is often possible to determine weave or knit pattern and yarn construction.
 - c. It is sometimes possible to determine composition and original color (checking where two yarns cross, inner position of seams, etc.).
 - d. Look for portions of seams, hems, pockets, snaps, zippers, buttons, rivets, etc.
 - e. Sizes can sometimes be determined from portions of a garment.
 - f. With ultraviolet and infrared lighting techniques writing or printing (e.g. labels, laundry markings) can sometimes be restored or made visible.
5. Physically matching a known fabric (or yarn) specimen with a question fabric (or yarn) specimen.
 - a. Perform a preliminary examination of the known fabric specimen.
 - i. Locate all damaged areas.
 - Determine if any yarns are missing from any of the areas.
 - Look for any foreign matter (fibers, paint chips, etc.) and stains in these areas that may be similar to foreign matter and stains on the question fabric specimen.
 - ii. Determine the size and shape of the missing portions.
 - The number of warp and filling yarns should be equal to or greater than those in the question fabric specimen.
 - Check the contour for long and short yarns, noting types and colors of yarns.

b. Side by side comparison of known fabric specimen and question fabric specimen.

i. Use caution in handling the known and question fabric specimens.

- Loosely fitting yarns just barely attached can easily be transferred between the known and question fabric specimens.
- A small question fabric specimen can be placed between two pieces of glass or clear plastic before bringing it into contact with the known fabric specimen for comparison (if necessary).

ii. Determine the correct position.

- "Right" or "wrong" side of fabric.
- Direction of warp vs. filling yarns (or course vs. wales).
- Line up irregular contours.
- Line up different types, sizes, and colors of yarns.
- Line up design patterns.
- Line up stain patterns.

iii. Look for the best "points of identification".

- Match most obvious first.
- Continue matching each yarn along the torn or cut edges until you are convinced that the question fabric specimen physically matches the known fabric specimen.

fabric

c. Sketch (diagram) and/or photograph the question fabric specimen and the area of the known fabric specimen from which the question fabric specimen originated, as well as the question and known fabric specimen matched together.

d. If the question fabric specimen and the known fabric specimen are positively "matched" together they must also be alike in color, construction, and composition.

6. Comparison of a question fabric specimen with a known fabric specimen in which there are no matching edges.

a. Construction and thickness of each fabric.

i. Determine type of weave, knit, etc.

- Diagram a complete weave or knit pattern.
- Number, size, color, and construction of yarns in each direction.

ii. Determine design patterns.

- A colored design may have been printed or formed by the weaving or knitting of different colored yarns.
- A non-colored design may be formed by different types and sizes of yarn or by cut and/or uncut pile.

iii. Determine yarn counts in each direction.

b. Composition and color of each fabric.

i. Check for different types and colors of yarn (warp and filling). See Yarn Analysis section.

ii. Identify and compare all fibers of each yarn type. See Fiber Analysis section.

iii. Look for repeats of manufacturer's "flaws", such as a missing portion of a print design.

c. Comparisons other than the fabric itself.

i. Foreign matter and stains.

ii. Sewing threads and stitching holes.

iii. Accessories, mended areas, etc.

FABRIC IMPRESSIONS

1. Preliminary examination of the question specimen.

a. Examination may be of the question item bearing the actual impression, a "lift" of an impressions or a "cast" of an impression (from various types of surfaces, e.g. mud, glass, fender).

- I. Impressions caused by force such as an auto striking a person or person falling in mud.
- ii. Impressions left in blood, soil, grease, etc. (On sheet, wall, etc.)
- iii. Latent impressions (lifted, by dusting, with tape).

b. First look for fibers and bits of yarn (use Stereomicroscope).

- I. Embedded in or on the actual impression, the "lift", or the "cast".
- ii. More than one type of impression may be present (e.g. an area including trouser top, belt, and shirt).
- iii. Carefully remove fibers from each type of impression separately, so as not to mark the impression itself.

c. Study the general shape of the impression.

I. Glove impressions.

- "Shapes" of fingers, thumb, and palm.
- Fabric, leather, or plastic.
 - Seams, stitching and creases may show with fabric.
 - An impression of an old cracked and creased leather glove may be as characteristic as an actual palm print and could be positively identified.
- Plastic gloves often leave design patterns of dots, lines, etc.

ii. Clothing impressions.

- Identify type of fabric.
 - Woven, knitted, or other
 - Ribs, loops, etc.
- Look for portions of a garment which were stitched or otherwise attached to it (e.g. hem, seam, pocket, collar, cuff, belt loop, buttonhole, button, patches, trim).
- Look for damaged areas (e.g. cuts, tears, snags).
- Look for creases, pleats, and mended areas.

2. Preliminary examinations of known or glove garment.

- a. Look for damaged, soiled, or stained areas.
- b. Look for patterns as seen in the question specimen.
- c. Make impressions of the known specimen.

I. Different areas believed to be similar to the question specimen.

ii. Use different amounts of force or pressure.

iii. Types of impressions.

- Inked
- Modeling clay
- Duplicast

3. Comparison of question and known impressions.

- a. Count the number of "ribs" per inch in each direction.
- b. Count the number of yarns or loops per inch in each direction.
- c. Determine direction of twist of the yarns.

- d. The known could have made the question impression if both the question and known impression are alike in all points of comparison. Only if sufficient unusual points of identification are found, can a positive identification be made.

BUTTONS

1. If no sewing thread is attached to a questions button:
 - a. Carefully remove all fibers (and other matter) from surfaces and within holes.
 - b. Determine size, shape, and color of button.
2. If sewing thread is attached to a question button:
 - a. Carefully remove loose fibers (and other matter) adhering to the thread and button, without disturbing the fibers which compose the thread or attached fabric and yarns.
 - b. Note any bloodstains, etc.
 - c. Note type(s) of fabric and yarn between the thread and the button.
 - d. Note type of thread and how it is attached to the button.
 - e. Photograph or diagram both sides of button with thread and any attached fabric or yarn before attempting to "take it apart".
 - f. It is usually not necessary to "take it apart" unless a known is available for comparison.
 - g. Do not disturb shapes, contours, or design of fabrics, yarn or threads when testing for composition.
3. Check victim's clothing as a possible source of the question button.
4. Comparison with "suspect garment".
 - a. Carefully check every button area of the known suspect garment where a button is missing.
 - i. Broken and/or missing yarn.
 - ii. Any remaining sewing thread.
 - iii. Foreign fibers (or other matter) and stains similar to those on the question button.

- b. Determine which areas of the known could be the source of the question button.
 - i. Number of layers of fabric present at the button area (facing, lining, interlining, etc.).
 - ii. Number and approximate length of missing warp and filling yarns from each layer.
 - iii. Types and colors of missing yarns from each layer.
 - iv. Note any stitching that might cross the path of the button area, where thread is missing.
- c. Compare the question and known sewing thread.
 - i. Manner in which attached (machine or by hand, number of loops through each set of holes, direction of loops, etc.).
 - ii. Type of knot(s).
 - iii. Construction, color, and composition.
 - iv. If all sewing thread does not remain on either the button or the garment, compare the amounts remaining between the question and the known.
- d. Remove sewing thread from the question.
 - i. Sever thread where looped over top of button.
 - ii. Carefully ease the thread (with attached fabric and/or yarns) from the button.
- e. Remove fabric and/or yarn from the question thread.
 - i. Carefully ease the thread from the layers of fabric.
 - Thread often extends through the yarns.
 - Note which yarns and/or fabrics are in the top closest to the button), middle, and bottom positions.
 - Notes directions and positions of each layer.

ii. Separate each layer.

- Keep in same positions
- Place between two glass slides (or clear plastic).

iii. Compare each layer with the corresponding layers.

****In the button area of the known garment.**

- Remember which surfaces were on top.
- Remember that the "wrong side" of the facing fabric will be on top.
- Attempt to physically match the question fabric layers.

5. "Replacement Buttons".

- a. A question button and/or the sewing thread on a button may differ from other buttons and/or sewing thread on the known garment from which it was torn.
- b. Fabric from such a question button may be positively matched to the known garment.

6. Points of comparison.

a. Button.

- i. Size and other measurements such as thickness.
- ii. Shape and design.
- iii. Color.
- iv. Composition.
- v. Manufacturer's markings.

b. Sewing thread.

- i. Manner in which it is attached.
- ii. Construction.
- iii. Color.

iv. Composition.

c. Fabric.

i. Color, construction, and composition.

ii. Usually can be physically matched if not damaged or altered.

d. Yarns.

i. Color, construction, and composition.

ii. Sometimes can be physically matched.

e. Fibers.

1. Color, type, and composition.

2. Usually can be microscopically matched to the known fibers as a possible source.

TAPES (adhesive)

1. Numerous types of adhesive tapes are produced, each including a wide variety of different characteristics.
 - a. Cloth adhesive tapes includes various colors and types, such as common white adhesive tape and black friction tape. Cloth adhesive tapes may have various types of plastic coatings or metalized coatings (such as duct tape) which includes a variety of surface characteristics.
 - b. Reinforced tapes of strapping tapes include various compositions (plastic, paper, etc.) and contain yarns or filaments of various compositions (glass, rayon, etc.)
 - c. Double-faced tapes include paper, cloth, and plastic.
 - d. Paper tapes such as masking tape, include various characteristics concerning there surface, color, and adhesive.
 - e. Plastic tapes and electrical tapes include transparent, translucent, and different colors.
 - f. Cellophane tapes include transparent, translucent, and different colors.
 - g. Other types of adhesive tapes include foam tapes, splicing tapes, decorative tapes and other special tapes.
2. Preliminary examination of question adhesive tapes.
 - a. If no known adhesive tape is received for comparison.
 - i. General type or types and color(s).
 - ii. Width(s) and whether torn lengthwise from a wider piece.
 - iii. Whether or not ends are cut, torn, and suitable for future matching purposes.

b. Comparison of question and known tapes.

i. Likeness of physical characteristics.

(Use stereomicroscope)

- Texture of plastic or plastic like surfaces-
shapes and spacings of indentations or other
markings.
- Width and thickness.
- Yarn counts (warp and filling) and yarn
irregularities.
- Color (surface, yarns, adhesive).
- Foreign fibers or particles.

ii. Comparison of microscopic characteristics.

- Identify and compare fiber type(s) (See
Fiber and Yarn Analysis) in yarns.
- Measure and compare film thickness.

iii. Perform infrared and spectral analysis.

- Adhesive.
- Plastic films (with or without colorants)
- Fibers or yarns (if sufficient sample is
present).

iv. Physically matching ends.

- Expose all question and known ends for viewing
(it may be necessary to align warp yarns
and/or remove excess adhesive.
- First look for the obvious irregular cut or
torn ends.
- Align the question and known contours.
- Align the short and long yarns.
- Align thick and thin yarns.
- Align nicks (contours) and scratches of
plastic edges (includes roller and mandrel
markings).
- Check all "points of comparison" of the
question end with the known end under the
stereomicroscope for a positive match.

CORDAGE

1. Some common, generally acceptable terms of cordage.
 - a. Rope - either twisted or braided; usually more than 3/16" in diameter (1" in circumference).
 - b. Twine - usually twisted; usually 3/16" or less in diameter; usually not a compact structure.
 - c. Cord - generally round or tubular braided, but may be twisted; usually 3/16" in diameter; usually a compact structure.
 - d. Line - usually refers to either a monofilament or small braided line used for fishing.
 - e. "Core" - often found in "braided cordage"; sometimes found in "twisted cordage" (usually of 4 or more plies); the center of the cordage - not one of (or part of) the plies or braids of the cordage; usually of a different construction and/or composition from that of the remainder of the cordage.
 - f. "Tracer" - usually a yarn (or yarns) of a different color and/or size and/or composition to that of the basic cordage; it may be present either within or along side the "core" or either within or along side a ply, strand, or braid.
 - g. "Coatings" on cordage - the outer surfaces of cordage are sometimes covered with a plastic; starch based material, or some other type of material; this "coating" often serves either to "waterproof" or to "strengthen" the cordage.
2. Preliminary examination of cordage.
 - a. Check for stains and debris.
 - b. Check ends.
 - i. How they were severed.

ii. Whether sufficient characteristics for matching purposes.

- Irregular contours (long and short yarns, jagged plastic edges, "cores", etc.).
- Variety of yarn types, sizes and/or colors.
- Determine diameter (and length, if pertinent)
- Determine types of knots, if pertinent.
- If ends are of value for possible matching purposes.

- Do not unravel ends or cut yarns or fibers from ends (leave "as is").

- After measuring entire length of cordage, remove a measured section (e.g. one inch) from a logical area (not near end, knot, etc.).

- * Tape the remaining cut ends together and mark (cut in lab., etc.)

- "Twisted" cordage - construction.

- Definition.

"Twisted" cordage (such as string, binder twine or sisal rope) usually contains three or more plies twisted together in a "spiral", either a "Z" or "S" direction of twist.

having
However,
twisted together
Each ply of the
contain two or more
can be "single" or
"plies". The terms "ply" and

it may consist of only two plies
or of a single twisted ply.
cordage can be "single" or
"strands". Each "Strand"
contain two or more

"strand" can be used alternately until one of them becomes a "single" ply or strand. A "single" or strand consists of a group of fibers

ply
(usually

twisted together), but sometimes un-twisted).

The direction of twist, between a set of plies and a set of strands, usually alternates.

Both
within
within each set
example, a three-ply
within one ply and five

the sizes and the numbers of "strands"
each set of "plies" (or "plies"
of "strands") can vary. For
rope may have six strands

strands within each of the other two plies. It

"plies"
and/or
the sizes

is, therefore, important to count all the
and/or "strands" within every "strand"
"ply", also noting any variations in

of them. Twisted cordage may or may not have a
"coating", "core", and/or a "tracer".

- Examination of "twisted" cordage.

- Tightness of twist and "crowns" per inch or centimeter.
- Coating (color, type).
- Number of plies and direction they are twisted (number of strands in each ply and direction they are twisted together, and so on until a single ply yarn is reached containing twisted in an "S" or "Z" direction.
- Core (number, size, color, twist, coating, etc.)
- Tracer (number, size, color, twist, location, etc.)

fibers

- "Braided" cordage - construction.

- Definition.

"Braided" cordage has a "sheath" consisting of a round or tubular fabric formed by "braids" (one or several yarns) having been intertwined (woven). It may be empty ("hollowcore") or sheath may surround a "core". It may or have a coating. A "tracer" may be into either the "core" or the placed between them.

the
may not
incorporated
"sheath" or be

- Examination of "braided" cordage.

- Tightness of sheath.
- Coating (color, type).
- Number of braids (both directions).
- Number of yarns in each "braid", whether twisted together and construction of each yarn, ply, within each braid.
- Core (hollow, number, size, color, twist, coating, etc.)
- Tracer (number, size, color, twist, location, etc.).

etc.

- "Plastic" cordage - construction.

- Definition.
A "tubing" consisting of a plastic "sheath"
usually surrounding a fibrous core.

- Examination of "plastic" cordage.

- Plastic ends usually bear markings suitable for physical match purposes (protect them).
- Color, thickness, and type of "sheath".
- Core (length in relation to end of "sheath"; number, size, color, twist, etc.).
- Tracer (size, color, twist, etc.).

- Composition of cordage.

- If ends are suitable for physical match purposes, do not remove fibers or yarn from end.
- If cord has a core.
 - * Bend a middle section into a "U" shape and tightly tape cord together about an inch the bend.
 - * At the bend area, carefully cut out a section of the sheath and core for construction and composition tests.
 - * Cores will often slip out of the sheath.
- Match irregular lengths of yarns and cores.
- Folded paper cores can be taken out for physical match purposes (in some cases, it is better to remove the paper core and unfold for better viewing).
- Plastic sheaths may have "toolmarks".

- If ends are not suitable for matching purposes, obtain construction and composition (See Fiber Analysis Section) after measuring the length.

- Some of fibers or filaments found in cordage:

- | | |
|-------------------------|--------------------------|
| - <u>Natural fibers</u> | - <u>Man-made fibers</u> |
| - Manila (Abaca) | - Nylon |
| - Sisal | - Olefin |
| - Hemp | - Polyester |
| - Flax | - Rayon |
| - Cotton | - Glass |
| - Jute | |
| - Coir | |

from