Comparison of Tire Impressions

1. Scope

The purpose of conducting a tire impression examination is to associate/disassociate a tire with questioned impressions at the scene of a crime. Objectives of the tire impression examinations conducted in the laboratory may include the following:

Comparison of the questioned impression with the tread pattern of the tires for agreement in class characteristics (i.e. tread pattern, size, and general wear).

Comparison of the questioned impression with the tread pattern of tires for positive identification through individual characteristics (i.e. cuts or gouges found in the tread).

Comparisons of the questioned impressions with submitted tires for elimination.

2. Terms and Definitions

Aspect ratio – The ratio that expresses a tire's section height to section width proportion. If a tire's sidewall height were 55% of its section width, its aspect ratio would be 55. In the tire size expressed as 205/55-15, the number 55 is the aspect ratio.

Bald tire – A tire that has worn away all of its tread design or that has been manufactured without any tread design.

Beads – Two rubber insulated multi-stranded hoops made of very strong steel wires that hold the tire on the rim.

Belts – Two wide strips of rubber-coated steel wires placed circumferentially over the plies and just beneath the tread. They reinforce the tread area, provide puncture resistance, and help the tire make better contact with the road.

Directional tread – Direction tread designs are those having a "one-way" tread pattern that is optimized to work best when rotating in one direction only. Arrows or other symbols are on the sidewalls and indicate the direction of rotation, which determines the side of the vehicle they are mounted on.

DOT number – A series of molded letters and numbers in the sidewalls of all tires, prefixed by the letters “DOT” and mandated by the U.S. Department of Transportation.

Footprint – The contact area, a tire tread makes against a flat surface when under load. Also known as a contact patch.

Green tire – The completely built tire before it goes through the vulcanization in the mold cure process.

Grooves – The space or channels between the tread ribs and elements. Circumferential grooves run around the circumference of the tire. Grooves allow for water to be channeled from beneath the tire’s surface.

Mold – The cavity that contains the tread and sidewall designs that are transferred to the green tire under heat and pressure in a process known as vulcanization.

Noise treatment – The tire industry’s effort to reduce noise generated by tires, particularly using a mixed arrangement of tread block sizes.

Notches – Small void areas that extend off of grooves or slots.

Pitch Sequence – The arrangement of tread blocks of varied sizes to reduce tire noise.

Ply – Rubber-coated parallel cord fabric that is placed over the liner and forms the tire carcass when locked around the beads.

Retread – A used tire to which new tread has been added.

Rib – A row of continuous rubber or disconnected tread blocks that run circumferentially around a tire to form the tread pattern.

Rotation – The practice of moving tires from side to side or front to rear on a vehicle in a prescribed way to achieve uniform wear on all tires.

Shoulder – The portion of the tire where the sidewall and tread meet and provides continuous contact with the road, especially during sharp maneuvers.

Sidewall – The sides of the tire that connect the tread and the bead.

Sipes – Small, slit-like grooves molded in tread blocks and/or ribs. They add flexibility by allowing more movement and provide additional traction edges, thus increase traction.

Tread – The designed part of the tire that comes into contact with the road.

Tread wear indicator – Bands of raised rubber, sometimes called “wear bars” that are 2/32 inches above the bottom of the main grooves.

Vent holes – Small holes drilled in the tread and sidewall surfaces of a mold to allow for air to escape during the mold cure.

Vehicle - for purposes of this standard operating procedure, any means of transportation that utilizes tires.

3. References

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Bodziak, W.J., FBI Academy; September 1989 Detection and Examination of Footwear Evidence School.

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4. Examination Procedures

4.1. Evidence Types

Evidence can include but is not limited to: photographs, negatives, and/or digital images of tire impressions, casts of tire impressions, objects containing tire impressions, lifts of tire impressions, tires on cars, trucks, ATVs and bicycles associated with a crime.

4.2. Instruments and Equipment

Gelatin lifters
Electrostatic lifter with Mylar
Adhesive acetate paper
Non-adhesive acetate paper
Black fingerprint powder and brush
Ruler
Spray bottle
Artist board
Rolls of clear acetate
Tape
Petroleum Jelly
Magnetic powder and brushes
Fingerprint palm lifters and acetate page protectors
Vacuum box w/ accessories
Dental stone, water, plastic zip-lock bags
Photographic equipment and accessories
Computer system with Adobe Photoshop and Foray Calibration filter
Soft bristle scrub and/or toothbrush
SICAR database (includes tire tread data)
MikroTrack (bubber or equivalent)

4.3. Reagents and Chemicals

Potassium Thiocyanate
Ammonium Thiocyanate
Fixative Solution - 2% w/v 5-Sulphosalicylic Acid
0.2% w/v Amido Black in 0.1M Citric Acid

Leucocrystal violet
Acetone
Hydrochloric acid
Nitric Acid
5-Sulphosalicylic acid
3% Hydrogen Peroxide
Sodium Acetate

All chemicals and reagents will be ACS grade with the exception of 3% Hydrogen Peroxide that can be USP grade.

All chemical enhancement mixtures will be verified before using on evidence.

4.4. Reagent Preparation

4.4.1. **Potassium Thiocyanate**

Dissolve 10g of potassium thiocyanate in 10mL of purified water. Add 80mL of acetone and slowly add 10mL hydrochloric acid. A white precipitate will form. Allow the mixture stand until the precipitate settles to the bottom. A clear liquid will remain at the top. The liquid is the reagent. Carefully decant the liquid into a separate container and discard the bottom residue. If the liquid reagent has a reddish tinge, the reagent is contaminated with iron. It shall be discarded and fresh reagent made. Properly label reagent container and document reagent preparation in the Microanalysis Reagent Logbook. *(International Symposium*, 1994) Verify the reagent is working properly prior to use in casework by spraying a small soil stained area not associated with the print or a sample prepared in the laboratory with dirt. The soiled area should turn red/pink. If the reagent does not react, try another soiled area or a sample prepared in the laboratory with dirt. If this area does not react, discard reagent, remake reagent with original chemicals and retest. Remake reagent with new chemicals and retest. Consult with Unit Supervisor as to next steps should the reagent fail again.

4.4.2. **Ammonium Thiocyanate**

Dissolve 2g of ammonium thiocyanate in 90mL of acetone. Add 10mL of nitric acid (2N or dilute) to the ammonium thiocyanate. No precipitation will result. The entire mixture should be sprayed onto the impression. Properly label reagent container and document

reagent preparation in Microanalysis Reagent Logbook (Bodziak, FBI Academy,1989)
Verify that the reagent is working properly prior to use in casework by spraying a small soil stained area not associated with the print or a sample prepared in the laboratory with dirt. The soiled area should turn red/pink. If the reagent does not react, try another soiled area or a sample prepared in the laboratory with dirt. If this area does not react, discard reagent, remake reagent with original chemicals and retest. Remake with new chemicals and retest. Consult with Unit Supervisor as to next steps should the reagent fail again.

4.4.3. **Leucocrystal violet**

Combine 10g of 5-sulfosalicylic acid with 500mL 3% hydrogen peroxide and place into a 500mL bottle. Add and dissolve 4.4g sodium acetate. Add and dissolve 1.1g of leucocrystal violet. The working solution should be stored in amber glassware and refrigerated. Properly label the reagent container and document the reagent preparation in the Microanalysis Reagent Logbook. The working solution should last approximately 3 months. The working solution shall be verified before use. (Bodziak, Footwear Impression Evidence, p.145, 146, 163.)
Verify the reagent is working properly prior to using in casework by applying reagent to a small blood stained area not associated with the print or a sample prepared in the laboratory with blood. The blood stained area should turn purple. If the reagent does not react, try another blood stained area or a known blood stain made in the laboratory. If this area does not react, discard reagent, remake reagent with original chemicals and retest. Remake with new chemicals and retest. Consult with Unit Supervisor as to next steps should the reagent fail again.

4.4.4. **Fixative Solution**

Prepare a 2% w/v aqueous solution of 5-sulphosalicyclic acid (2g in 100mL of purified water, 20 grams in 1000mL of purified water, etc.) in glass container. Properly label the container and document reagent preparation in Microanalysis Reagent Logbook. The fixative solution is used in conjunction with Amido Black reagent. No verification is required prior to use. Should the fixative not perform properly with blood stained items then the solution shall be

remade and retested. Consult with Unit Supervisor as to next steps should the reagent fail again.

4.4.5. Amido Black Staining Solution

0.1M Citric Acid
Dissolve 10.5g of citric acid in 500mL of purified water.

0.2% w/v solution of amido black in 0.1M citric acid.
Dissolve 1g of amido black in the citric acid solution.
Properly label the reagent container and document the reagent preparation in the Microanalysis Reagent Logbook. Verify the reagent is working properly prior to use in casework by applying the reagent to a small blood stained area not associated with the print or a sample prepared in the laboratory with blood. The blood stained area should turn bluish in color. If the reagent does not react, try another blood stained area or a stain made with known blood. If this area does not react, discard reagent, remake reagent with original chemicals and retest. Remake with new chemicals and retest. Consult with Unit Supervisor as to next steps should the reagent fail again.
(CRE Report No. 649,1988, and CRE Report No. 684, 1989)

4.5. Procedural and Chemical Precautions

Refer to the TBI Safety Manual for general safety requirements and hazard information regarding the use of reagents and solvents, and overall safety guidelines.

Protective attire, including laboratory coat, mask, gloves and eye protection should be used when working with clothing and/or bloodstained items.

Decontamination of a scientist's work area should be performed after each use, but shall be done after analyzing bloodstained items.

Hazardous chemicals shall be used in a chemical fume hood.

When handling concentrated acids, eye protection and laboratory coats shall be worn.

When diluting acids, always add acid to water.

When necessary, consult section and laboratory Material Safety Data Sheets (MSDS) regarding any chemical used in the Microanalysis section.

Label all generated solutions and reagents with appropriate warning stickers.

4.6. Limitations

When performing comparisons using photographs, the examiner's analysis and results may be limited by the quality of the images submitted. Investigative information (i.e. manufacturer or model) is limited to running the tire impression through the Shoeprint Image Capture and Retrieval (SICAR) database and/or the Tread Assist software or Tread Design Guides.

4.7. Procedure

Document submitted samples according to *Microanalysis Quality Assurance Policy*.

4.7.1. Photographs/Negatives/Digital Images of unknown impression(s) submitted by an outside agency

Determine if the photographs/negatives/digital images are of examination quality. Images shall contain a measuring device, be taken from a 90-degree angle to the impression with the camera back parallel to the impression.

If the impression(s) and the tires appear to have a similar tread design, print black and white photographs and/or transparencies of the impression to actual size. If the transparency is hard to see through, a hand drawn copy of the tire track can be obtained instead of the photographs and transparencies. This is accomplished by tracing the tread pattern using clear acetate laying over the cast, photograph or lift of the tire impression from the scene. To scale enlargements will be generated using the Foray Calibration filter and Adobe Photoshop. This program will size the image at a true and accurate life-size scale. The photographs are check for scale with the corresponding ruler.

4.7.2. Tire Impression on an Item

A tire impression on an item shall be photographed for future comparison or be captured by a flatbed scanner when applicable. The impression should be imaged using a RAW format or a suitable high resolution format. The camera shall be mounted on a camera stand or

tripod to prevent movement. The camera should be adjusted as close to the image as possible allowing for focus to be able to fill the frame. The image plane should be centered over and parallel to the scale. When using a flatbed scanner, place the evidence with the impression on the scanner, along with a scale, and make a preview scan. Crop the image appropriately and rescan. Capture the image and evaluate it.

When these images are transferred to the computer an original file is made and a working file is made. The original file is never opened or changed. All enhancements made in Adobe Photoshop will be in the working file. These files will be backed up on the external hard drive and a DVD will be made (both these processes occur when space is needed on the internal hard drive). The DVD will be stored in a secure location in the Microanalysis section.

4.7.3. Enhancement and Lifting of Tire Impressions

Photograph tire impressions prior to enhancement.

Tire impressions made from dirt residue on a porous surface can be enhanced using a potassium or ammonium thiocyanate reagent. The tire impressions shall be photographed again after enhancement, if additional detail was developed.

Tire impressions in blood can be enhanced using the 0.2% w/v amido black reagent. The tire impressions shall be photographed again after enhancement, if additional detail was developed.

With the electrostatic lifting device, impressions can be lifted from virtually any surface, both porous and nonporous. The device works best on dry dust or dry residue impressions and latent impressions from surfaces where suspected impressions may be present. If the electrostatic lifter is needed, attach the probe and the ground wires (color coded) to the base unit. Attach the ground to a metal surface (i.e. latch on case). Cut a piece of Mylar film to fit the impression. Place the Mylar black side down on the impression. Turn on the unit and touch the Mylar with the probe. The film should be pulled down tightly against the impression surface. If this doesn't happen, place one of the metal plates along the side of the impression for conduction. Use the roller to go across the film to get rid of any bubbles. Turn off the unit and touch the probe to a metal surface. Lift the film and place

it black side up into a flat box. Tape the film to the box to secure the film.

Fingerprint powders may be used to enhance tire impressions that result from a damp or wet tire tracking on clean, nonporous surfaces. Whenever the impression is detected prior to powdering, photograph first. A very small portion of the impression should be powdered first to determine if the technique would be successful. If it is, the remainder of the impression can be powdered. The powered impression can be photographed and/or lifted.

In cases where it is suspected that impressions may be present on papers, a vacuum box may be used to recover the impression(s). Place the paper with the impression on the vacuum box and cover it with the clear Type SP plastic film. Switch on the fan and the vacuum will eliminate air gaps. Charge the film with the corona unit (wand) for 10 to 15 seconds. Switch off the unit. Examine the film for tire impressions using side lighting. If any are observed, photograph them.

4.7.4. Casts of tire impressions

When casts of tire impressions are submitted, it may be necessary to clean them before analysis. A tooth/scrub brush may be used in cases of hard to remove debris. Care should be taken not to use a brush that is so abrasive as to damage the cast surface. A photograph of the impression must be taken. These photographs may be used for comparison purposes or used solely for documentation. If the photographs are to be used for the actual comparison, then they are enlarged to scale. See the procedure for capturing an image of an impression on an item above.

4.7.5. Analysis of unknown tire impressions

Analyze unknown tire impressions for comparison quality. Document suitability of the impressions for comparison in case notes.

4.7.6. Visual Examination of submitted vehicle

Visually compare submitted items, photographs, and casts to the tires on submitted vehicles, or submitted tire test impressions.

If the impression(s) and the tires appear to have a similar tread design, print black and white photographs and/or transparencies of the

impression to actual size. If the transparency is hard to see through, a hand drawn copy of the tire track can be obtained instead of the photographs and transparencies. This is accomplished by tracing the tread pattern using clear acetate laying over the cast, photograph or lift of the tire impression from the scene. To scale enlargements will be generated using the Foray Calibration filter and Adobe Photoshop. This program will size the image at a true and accurate life-size scale. The photographs are check for scale with the corresponding ruler.

If photographic negatives or digital images are submitted, enlarge the photographs enough to see tread design detail. If the tread pattern is inconsistent, then it is not necessary to enlarge the images to scale. If they are inconsistent, document and photograph thoroughly. Testing is complete and a report is generated. If they appear to be similar refer to **13.3.6.1**. If casts are submitted, clean the casts and photograph. If the tire impression on the cast has an inconsistent tread design with the tires from the vehicle, then a documentation photograph is sufficient. A report is generated without further analysis.

If an item is submitted with a tire impression, preserve the impression using any of the following techniques: photography, lifting and/or casting. If the impression is inconsistent, then a report is generated without further analysis.

If there is a negative association between the vehicle tires and the crime scene impression then photograph the tread pattern on the tires and any spare tires in and on the submitted vehicles. These photographs are part of the case file. If all the tires have the same tread design, then it is not necessary to photograph all four tires. One representative photograph is sufficient.

(Optional) Lightly dust a representative area of each tire. Using adhesive acetate or palm lifters, acquire a test impression from the tire. These are part of the case file notes. If all the tires have the same tread design, it is not necessary to print all four tires.

4.7.7. Two dimensional known tire test impressions

The vehicle tires need to be dry and at room temperature.

Clean the tire with a cloth to remove loose dirt. Do not pry rocks out of tread and clean the floor where the art board is to be laid.

Apply petroleum jelly sparingly to the complete width of the tire and as much of the circumference as possible.

Position the art board and PUSH the car to record the first few feet of the tire impression. Stop Vehicle!!! Clean and apply petroleum jelly to the area of the tire that was on the ground when you began.

Continue for almost one complete revolution. Stop and insert a third board (if needed for larger tires) and remove the first board (if necessary) to prevent front or rear tires from rolling over it.

Document the art board with the tire information, the direction the vehicle would roll in a forward motion, the D.O.T. number, the laboratory case number (if available), examiners initials and the date.

Dust the test impression with black magnetic fingerprint powder and cover the test impression with clear acetate (plastic) for protection.

4.7.8. Three dimensional known tire test impressions

At times it can be helpful to make a three-dimensional test impression of a tire in order to effectively compare that tire with a three-dimensional questioned impression. A similar substrate should be used as in the original impression (i.e., dirt, sand, snow, etc.). MikroTrack (bubber or equivalent) may also be used to form a three dimensional impression. Use dental stone to cast the tire track produced.

4.7.8.1. Mixing dental stone for casting impressions
Place dental stone in large zip-lock bag. Dental stone's powder to water ratio is approximately 6oz. of water to 1lb of powder. Mix the casting material by massaging and gently kneading the bag. The proper viscosity should be that of pancake batter. Adjust with water and dental stone until consistency is perfected.

4.7.8.2. Pouring the cast material
When pouring the casting material from the ziplock bags, the bag should be placed next to the impression so that the casting material does not cascade onto the impression, but instead, falls on the adjacent ground after which it will flow into impression. If the impression is on a slope, start pouring the material at the uphill part of the impression so that it will flow

downhill into the impression. The entire impression must be filled with casting material. Before the cast completely hardens, it is possible to scratch the date, your initials, and other needed information onto the back of it. As the cast hardens, it will be warm to the touch. When it is no longer emitting heat, the cast is ready to be lifted. When the time has come to lift the cast, care should be taken so as not to damage it. Allow the cast to air dry for 48 hours –The cast should be air dried at room temperature for at least 48 hours. After the cast is fully dried, it is ready for cleaning by the examiner. The thoroughly dried cast can be safely stored in a paper bag or cardboard box.

It is recommended that the vehicle with the tires be available during analysis to verify any individual characteristics found. This is not always possible. If individual characteristics are located and the vehicle is not at the laboratory, the submitting officer should be notified and the vehicle/tire be resubmitted. The examiner may choose to travel to the vehicle location to verify the match. Photographs of the outside of the tires including sidewall information and tread should be taken and kept as part of the case file notes.

4.7.9. **Analysis and Comparisons**

Comparison can be accomplished by overlapping the transparency or traced tread pattern from the scene over the tire test impressions from the vehicle. Move the transparency/ tracing along the full length of the test impressions noting areas of matching noise treatment. These areas are then searched for individual matching characteristics. The examiner may also determine the pitch sequence by measuring the elements along the circumference of the tire/test impression. This is compared with the pitch sequence of the impression and can aid the examiner in knowing how many areas along the tire could have made that impression.

Occasionally it may be easier to trace the tire test impression first and overlay this over the questioned track.
***Due to the size of the to scale photographs and transparencies used in tire impression comparisons, they cannot be stored as part of the case file. Therefore, all photographs and transparencies will be maintained in a secure location in the Microanalysis Section. This envelope will be referred to in LIMS as TP1. It will contain the

transparencies from the impression submitted and all photographs that were enlarged to scale and used in the examination. If during the examination, lifts or casts are made, these will also be associated with this packet. It will be the examiners responsibility to set up the TP1 in the LIMS system under the case number. This chain of custody starts with the examiner and continues until it is stored into the test impression secured cabinet in the Microanalysis section.

Characteristics for Comparison - There are two separate phases involved in an examination.

Determine similarities in class characteristics. The known and unknown impressions are compared with respect to size and tread design.

Determine if individual characteristics exist on both the impression and the tire. Individual characteristics are the cuts, tears, wear marks and randomly placed nails and flaws acquired after manufacturing, These individual/accidental characteristics result when something is randomly added to or taken away from a tire that either causes or contributes to making that tire unique. Random infers that the size, shape, and/or position of the characteristic depend, to some degree, on chance. The value of each characteristic depends on the clarity of the characteristic, it's reproducibility in the test impression, the random occurrence on the tire and it's degree of uniqueness.

A positive identification occurs when the questioned impression and the known tire share confirmed random characteristics that, by virtue of their features and placement on the tire, in the opinion of a qualified tire impression expert, could not be repeated on another tire sharing the same class characteristics. The positive identification means no other tire in the world could have made that particular impression.

4.7.10. Verifications

All impression evidence comparison cases will be blindly verified. A qualified impression examiner will get the case from the examiner that worked it without knowing their results. Since this will encompass all results from elimination to identification, the verifier shouldn't have any preconceived idea to the outcome. The verifier will use the photographs, test impressions, shoes and any other evidence necessary to render an opinion. The verifier will fill out the verification sheet with the required information. After the examination if finished,

the examiner and the verifier will compare their answers. Upon agreement, the examiner will enter their results into the LIMS system and the technical review and administrative review will be completed per regular procedure. If there should be minor discrepancies (example, not enough detail present), these can be discussed until an agreement between the two examiners is reached. If a major discrepancy develops (example, identification), the two examiners will either come to a compromise that both agree with (example, A lesser association that they can agree upon) or a third examiner or supervisor will become involved until an agreeable outcome is reached.

5. Measurement Traceability

Any reference to size is solely based on comparison of question to known. Any measurements taken during pitch sequence is used only for comparison and not a critical measurement to the examination.

6. Reference Materials

Yearly “Tread Assist” software, Bennett Garfield Publications
Yearly “Tread Design Guides”, Nancy Garfield Chychrun Publisher
SICAR (Shoeprint Image Capture and Retrieval) Database

7. Reports

The following are possible results concluded from the examination:

Physical comparison of known tire to tire impression represented by either/or the photographs, negatives, casts, or lifts revealed them to be consistent with respect to size and tread design. Therefore, the tire impression represented by the photographs or negatives or casts or lifts could have been made by the known tire. However, the lack of individual characteristics precludes a more conclusive comparison.

Physical comparison of known tire to the tire impression represented by either/or the photographs negatives, casts, or lifts revealed them to be inconsistent with respect to either/or both size and tread design. Therefore, the tire impression represented by the photographs or negatives or casts or lifts could not have been made by the known tire.

Physical comparison of known tire to the tire impression represented by either/or the photographs, negatives, casts, or lifts revealed them to be consistent with respect to size, tread design and individual characteristics. Therefore, the tire

impression represented by the photographs or negatives or casts or lifts was made by the known tire.

Additional information may be added such as tire manufacturer, make and model relative to each submitted case.

Physical comparison of the known tire with the tire impression represented by photographs revealed them to be inconclusive. They appear to have a similar tread design, however due to the condition of the photographs, a physical comparison was not possible.

Details exists but the features in the impression preclude a definitive opinion.

Insufficient detail was present in the questioned impression for a meaningful comparison.