FIREARM & TOOLMARK SECTION
STANDARD OPERATING PROCEDURES

Toolmark Examination Protocol

LISTED PROCEDURES

- Physical Examination & Classification of Tools
- Physical Examination & Classification of Toolmarks
- Trace Material Examination
- Test Marks
- Microscopic Comparisons
- Magnesium Smoking
- Casting
- Physical Fit Examinations

PHYSICAL EXAMINATION & CLASSIFICATION OF TOOLS

INTRODUCTION

The initial examination of a tool will include the completion of a tool worksheet. This worksheet will include the physical description of the tool. It will also serve as a source to document the condition of the evidence as received and any tests or comparisons performed with the tool.

SAFETY CONSIDERATIONS

This procedure does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this procedure to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use. Proper caution to include strict adherence to Universal Precautions and Blood Borne Pathogen safety must be exercised and the use of personal protective equipment must be considered to avoid exposure to any potential hazards.

PROCEDURE

A tool worksheet will be filed out. This may include noting the following:

1. If any trace material is present. If so, see Trace Material Examination below.
2. The class characteristics of the tool
3. The type of tool
4. The brand name of tool
5. The size of the tool
6. The condition of the tool
7. Areas of recent use visible on the tool
8. Type of tests conducted (if any)
9. The medium used for testing

10. A diagram or illustration of the tool showing mark producing areas.

PHYSICAL EXAMINATION & CLASSIFICATION OF TOOLMARKS

INTRODUCTION

In order to compare a questioned toolmark with a suspect tool, it is necessary to evaluate the toolmark. The initial examination of a toolmark will include the completion of a toolmark worksheet. This evaluation will consist of a physical evaluation and classification of the toolmark, and will help determine what course the rest of the examination should take. The basic objective in evaluating a questioned toolmark is to determine the suitability and classification of the toolmark. It will also serve as a source to document the condition of the evidence as received and any comparisons performed with the toolmark.

PROCEDURE

A systematic approach should be used for the physical examination and classification of questioned toolmarks. A toolmark worksheet will be filed out. Consideration should be given to:

1. If trace material is present. If so, see Trace Material Examination below.
2. The suitability of the toolmark for comparison purposes.
3. Class of tool that made the toolmark.
    a. Major and minor classes of toolmarks
    b. Physical characteristics of toolmarks
4. Direction of toolmark

INTERPRETATION OF RESULTS:

If the toolmark is suitable for comparison, the examination may continue.

If the toolmark has the same class characteristics as the suspect tool, the examination may continue.

TRACE MATERIAL EXAMINATION

INTRODUCTION

Tools and toolmarks recovered during an investigation may contain trace material transferred from the crime scene. This trace material may be in the form of blood, tissue, plaster, paint, hairs, fibers, glass, etc. The examiner needs to evaluate the importance of this evidence and, if further examination of the trace material is necessary, to remove and preserve a sample of the trace material present. Removal of trace material may also be necessary to allow the proper examination and testing of a tool. Removal may be done either by the toolmark examiner or an examiner in the section appropriate for the trace material.

SAFETY CONSIDERATIONS

This procedure does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this procedure to establish appropriate safety and health practices and to determine the applicability of regulatory limitations prior to use. Proper caution to include strict adherence to Universal Precautions and Blood Borne Pathogen safety must be exercised and the use of personal protective equipment must be considered to avoid exposure to any potential hazards.

NFPA LISTING				
CHEMICAL	HEALTH HAZARD	FLAMMABILITY HAZARD	REACTIVITY HAZARD	CONTACT HAZARD
15% Acetic Acid	2	2	3	
10% Bleach	2	0	1	
Methanol	1	3	0	
Acetone	1	3	0	

WARNING! Acetic acid is capable of detonation and can pose a **SEVERE REACTIVITY HAZARD**.

WARNING! Methanol is flammable and can pose a **SEVERE FLAMMABILITY HAZARD.**

WARNING! Acetone is flammable and can pose a **SEVERE FLAMMABILITY HAZARD**.

The examiner should use eye protection or work within a fume hood. The examiner may wish to consider wearing gloves.

PREPARATIONS

NOTE: ALWAYS ADD ACID TO WATER. NEVER ADD WATER TO ACID.

15% Acetic Acid Solution:
Prepare a 15% Acetic Acid Solution utilizing Concentrated Glacial Acetic Acid and distilled water.

10% Bleach Solution:
Prepare a 10% Bleach Solution utilizing Bleach and distilled water.

PROCEDURE

1. Examine the tool or toolmark visually and microscopically for any trace material and record in notes.

2. Determine if further examination of trace material is necessary. If so, remove material being careful not to damage the tool or toolmark. Place the removed trace material in a suitable container/packaging for submission to the appropriate section for further examination. If necessary, consult the appropriate section prior to the removal of any trace evidence. The examiner may wish to forward the tool/toolmark evidence to the appropriate section before continuing with the examination. If the trace material is not going to be retained for further examination, proceed with those of the following steps that are applicable.

3. For evidence containing blood, tissue or other biohazards, soak the evidence for at least one (1) minute in a 10% bleach solution.

4. Remove loose material by rinsing the tool with methanol or water.

5. Remove plaster by soaking the tool in a 15% acetic acid solution.

6. Remove paint by soaking the tool in alcohol or acetone.

TEST MARKS

INTRODUCTION

In order to compare a questioned toolmark with a suspect tool, test marks are usually made with the suspect tool. The basic objective in preparing test standards is to attempt to duplicate the manner in which the tool was used to produce the evidence or questioned toolmark.

SAFETY CONSIDERATIONS

The examiner should consider using eye protection.

PREPARATIONS

Test Media:

> The initial test media must be soft enough to prevent alterations of the tool's working surface. Lead is usually the material utilized. Subsequent tests might require the use of a harder test media to better reproduce the toolmarks.

PROCEDURE

A systematic approach should be used for the production of test marks or standards. Consideration should be given to:

1. Areas of recent use on the tool in question.
2. Direction of use.
3. Indexing of test standards/ marks.
4. Continue to Microscopic Comparison Method.

MICROSCOPIC COMPARISON

INTRODUCTION

In order for an examiner to identify a toolmark back to the tool that produced it, a microscopic comparison utilizing a comparison microscope must be performed. The comparison microscope allows the examiner to place the evidence on one side of the microscope and the known standard on the other side. This procedure may also be used to compare to unknown toolmarks together to determine if they were made by a single tool.

PROCEDURE

The steps listed below do not have to be performed in the order listed; however, all steps must be considered and/or addressed.

1. Select the correct objective (magnification) setting and ensure that the objectives are locked in place.
2. Select the correct set of oculars (eyepieces).

3. The illumination (lights) used must be properly adjusted. Oblique lighting is usually preferred.

4. Compare tests to first to establish reproducibility of class and individual characteristics.

5. Compare unknown toolmark to either another unknown toolmark or a known standard by placing the unknown toolmark on the left hand stage and the other unknown toolmark or known standard on the right hand stage.

6. The entire toolmark must be considered.

7. If an identification is not initially made, the examiner should consider the following factors:

    a. Angle of lights
    b. Type of lights
    c. The need for additional known standards
    d. The position of the evidence, the tests or both the evidence and the tests
    e. The possibility of using magnesium smoke
    f. The possibility of cleaning the tool

INTERPRETATION OF RESULTS:

IDENTIFICATION

When compared items exhibit agreement of a combination of individual characteristics and all discernable class characteristics where the extent of agreement exceeds that which can occur in the comparison of toolmarks made by different tools and is consistent with the agreement demonstrated by toolmarks known to have been produced by the same tool, the examiner will report an identification or that both items originated from the same source. In accordance with ASCLD-LAB requirements, sufficient notes or photomicrographs are required to document conclusions of a positive identification. A photomicrograph showing the correspondence of individual characteristics between exhibits will suffice to meet this requirement.

INCONCLUSIVE

When the examiner concludes that no identification or elimination is possible because the compared items exhibit (1) some agreement of individual characteristics and all discernable class characteristics, but insufficient for an identification; or (2) agreement of all discernable class characteristics without agreement or disagreement of individual characteristics due to an absence, insufficiency, or lack of reproducibility; or (3) agreement of all discernable class characteristics and disagreement of individual characteristics, but insufficient for an elimination. Within the category of no identification – no elimination there may be degrees of certainty expressed. No professional standard exists which limits an expression of likelihood. In accordance with ASCLD-LAB requirements, where no definitive conclusion can be reached, the report will clearly communicate the reason(s); e.g. insufficient agreement of individual characteristics, damage, etc. Photographs will not be required in the case of inconclusive findings, however notes will be sufficient to fully support the conclusion.

ELIMINATION

When compared items exhibit significant disagreement of discernable class characteristics and/or individual characteristics the examiner will report an elimination or that the items (evidence and tests) did not originate from the same source. Photographs will not be required in the case of an elimination, however notes will be sufficient to fully support the conclusion; however, it is strongly suggested that photographs be taken where eliminations are based on the disagreement of individual characteristics.

UNSUITABLE

A lack of suitable microscopic characteristics will lead the examiner to the conclusion that the items are not suitable for comparison. When evidence bears no marks suitable for microscopic comparison, the documentation of the determination will be recorded on worksheet.

VERIFICATION

It is the policy of this laboratory that (unless one is unavailable for an extended period) another qualified examiner will verify microscopic comparisons that result in a conclusion of a positive identification. This verification will be documented in the examiner's notes (verifying examiner's initials and date). Where multiple exhibits are all identified, a representative sample will be verified. It is not necessary to verify each exhibit.

It is suggested that any identification be indexed.

Once a positive identification is made of one tool mark, it will not be necessary to compare the remaining marks found on the object(s).

INSTRUMENTATION – ISO 17025 – 5.5.4

For purposes of ISO 17025 5.5.4 as of January 1, 2011, all examinations were performed with the equipment listed in Appendix D unless listed otherwise in the case notes.

MAGNESIUM SMOKING

INTRODUCTION

Magnesium smoking is a technique of reducing the glare of a shiny object by lightly coating the surface with fine magnesium smoke.

SAFETY CONSIDERATIONS

This procedure involves hazardous materials, operations and equipment. This procedure does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this procedure to establish appropriate safety and health practices and to determine the applicability of regulatory limitations prior to use. Proper caution must be exercised and the use of personal protective equipment must be considered to avoid exposure to hazardous conditions. Consult the appropriate MSDS for each chemical prior to use.

NFPA LISTING				
CHEMICAL	HEALTH HAZARD	FLAMMABILITY HAZARD	REACTIVITY HAZARD	CONTACT HAZARD
Magnesium Ribbon	1	4	3	

DANGER! Magnesium Ribbon is highly flammable and can pose an **EXTREME FLAMMABILITY HAZARD.**

WARNING! Magnesium Ribbon is capable of detonation and can pose a **SEVERE REACTIVITY HAZARD**.

The examiner should use eye protection or work within a fume hood.

PROCEDURE

1. Cut pieces off the roll of magnesium metal ribbon and place the remaining roll in a safe place.

2. Light Bunsen burner and place ashtray nearby.

3. Pick up a piece of ribbon with tweezers or forceps by grasping the ribbon as close to one end as possible.

5. Hold other end of the ribbon in the flame until it ignites.

6. With other hand, hold object upside down and 4-6" over the flame of the magnesium so the smoke can lightly cover the toolmark on the object. (Be sure to hold both the ribbon and the object over the ashtray so that debris from the burning ribbon will fall in it.) **NEVER LOOK DIRECTLY AT THE MAGNESIUM FLAME!!!!**

7. The coating should be light enough to see the color of the item smoked through the coating of smoke. If the object collects too much smoke, wipe the smoke off and repeat the process. For a lighter amount of smoke, pass the object back and forth through the smoke until the desired covering is achieved.

CASTING

INTRODUCTION

If an item received for a toolmark examination is too large to be conveniently placed on the microscope's stages a silicon rubber cast can be made of the toolmarks in question. There are also occasions when a cast of a toolmark might be received as evidence. In either case, any test standards made will also have to be casted in order to perform a comparison. *Mikrosil, Duplicast* or other types of silicon rubber casting material are similar products and procedurally are equivalent as long as the manufacturers instructions are followed.

PROCEDURE

1. Prepare the casting material as per manufacturer's specifications.
2. Cascade the casting material over the toolmark to be casted.
3. Allow the cast the appropriate amount of time to cure.
4. Gently lift the cast off the toolmark.
5. Consideration must be given to placing identifying marks as well as orientation marks on the back of the cast.

PHYSICAL FIT EXAMINATIONS

INTRODUCTION

The matching of broken, torn or cut objects can be encountered in almost any type of crime and can, potentially, end up in almost any laboratory section for examination. Physical fit comparisons, also known as physical match, fracture match, or jigsaw fit comparisons, are performed in an attempt to uniquely associate a piece of material with an item from which it is thought to have originated. If the separation involves random processes, the particular separation would not be expected to occur again in exactly the same way. In most cases physical fits are similar to putting together the pieces of a jig saw puzzle where edges and surface markings are used to align them. They sometimes involve demonstrating that two or more objects have a common origin where no evidence of an interlocking fit exists, such as a piece of wood that has been sawn apart. It can be "matched" due to size, grain structure, and growth rings, but the edges are different due to the saw kerf.

The process of matching broken or torn objects depends upon the type and size of them, whether an edge or whole surface is being compared and the number of pieces submitted for examination.
Evidence submitted for physical match comparisons must be composed of a material that is stable after separation. Very soft or elastic materials may not be suitable because they may become stretched or deformed at the separation line. Examples of materials that that would be suitable for physical match comparisons are glass, plastic, wood, metal and paint chips.

CRITERIA FOR CONDUCTING THIS TYPE OF EXAMINATION:

1. The exhibits are broken or torn into pieces and not designed to go back together.
2. The exhibits can be realigned. Some degree of rigidity is necessary. Items that wear, fray, or distort may not be capable of realignment.
3. The exhibits can be fit together edge to edge, via surface markings, or both.
4. The pieces are unique; that is, not interchangeable with similar pieces elsewhere.

EXAMINATION PROCEDURE

1. Document the condition and packaging of evidence as it is received. Evidence should be marked with the Firearms number and the examiner's initials.

2. If any significant trace materials are found (fibers, hair, blood, etc.) the item should be processed for the trace material prior to any physical comparison of that item. This will prevent any loss of cross transfer of material. This may be done by the firearms examiner, who will package the trace for later examination by the appropriate Laboratory Section, or by a criminalist from the Laboratory Section appropriate for the analysis type to be done.

3. Perform a visual examination (macroscopic/microscopic) of each of the items. Observations should be made regarding the class characteristics exhibited by each of the items. Examples of class characteristics would include the type of material (glass, plastic, etc.) color, texture, curvature and thickness. If the class characteristics of the items submitted for comparison are grossly different (e.g., headlamp glass versus window glass), it can be determined that the items did not originate from a common source. If the items exhibit similar class characteristics, then the examiner should proceed by examining and comparing the following:

   a. Edge to edge realignment depending upon rigidity of specimens, fracture edge distortion, and uniqueness.

   b. Types and alignment of surface markings such as manufacturing marks, polishing marks, accidental abrasions, surface pattern, print design, color sequence, and wording or lettering.

   c. Physical measurements of pattern to give basis for substantiating class characteristics and scientifically supporting opinion. These measurements would include length of the break, size or orientation of gross features, distance across edge(s), and relative location of other things such as surface markings, breaks through letters or numbers, other striations to each other, and the break.

4. Once the examiner has found similar shaped edges, the pieces are then tested by carefully holding them close together and in different positions. If a physical fit is found, the pieces will fit together in the manner of a jigsaw puzzle. The examiner should rely on the sense of touch as well as the sense of sight when performing this type of examination.

5. Once the examiner has fit two items together, he/she should examine the separation line (macroscopically/microscopically) for continuity of surface markings. Surface markings include pattern, striations, and/or any irregularities. They may be present on all surfaces of the separated edge (all three dimensions). Oblique lighting is helpful in this type of examination. This portion of the examination is especially important for items that have straight, featureless separation lines. If surface markings are present on the items at the separation line, but do not correspond, then no physical match exists between those items. However, if they are present, and if they are continuous across the separation line of the items which have been fit together, then it can be determined that a physical fit exists and that the items have a common origin.

Note: In cases involving a large number of questioned and known submissions, it is often easier to first reconstruct all the known items and all the questioned items prior to conducting any comparisons of questioned to known evidence.

6. If no physical match is determined to exist between the two items, but they exhibit similar class characteristics, it is possible that:

   a) they did not originate from a common source
   b) they originated from a common source, but connecting pieces of material are missing
   c) they originated from a common source but lacked sufficient characteristics for a positive physical fit.

   In order for the examiner to make any determinations regarding the possibility of a common origin in these circumstances, the examiner must rely on other types of examinations (physical and/or chemical)

specifically designed for the type of material to be compared (i.e., metal, paint, glass). The examiner should forward the items to the appropriate Laboratory Section for further analysis.

7. The examiner should document the results of his/her examination in the form of written notes, diagrams and/or photographs. In cases where a physical fit has been made and the items are of sufficient size, the examiner may draw a line with marker across the fracture line of the physically fit items and mark the same letter designation (A, B, C…) on each side of the line. This procedure is particularly helpful in cases involving multiple physical matches, especially if the items will require being reconstructed at a later date.

REFERENCES

TOOLMARKS

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2. Janneli, R.; Geyer, G. "Smoking a Bullet"; AFTE *Journal*, 9, 2, 128.

3. ANON. "Mikrosil Casting Material Information"; *AFTE Journal*, 15, 2, 80.

4. Barber, D.C.; Cassidy, F.H. "A New Dimension with (Mikrosil) Casting Material"; *AFTE Journal*, 19, 3, 328.

PHYSICAL FITS

1. DeForest, P.R., Gaensslen, R.E., and Lee, H.C., Forensic Science: An Introduction to Criminalistics, McGraw-Hill, NY, 1983.

2. Kirk, P.L., Crime Scene Investigation, 2nd. Ed., NY, John Wiley & Sons, 1974.

3. Safferstein, R. Ed., Forensic Science Handbook, NJ, Prentice-Hall, 1982.

4. Thornton, J., "Fractal Surfaces As Models of Physical Matches", Journal of Forensic Sciences, Vol. 31, No.4, 1986, pp. 1435-38.

5. VanHoven, H.A., Fraysier, H.D., "The Matching of Automotive Paint Chips by Surface Striation Alignment", Journal of Forensic Sciences, Vol. 28, No.2, 1983, pp. 463-67.

6. Zugibe, F., Costello, J., "The Jigsaw Puzzle Identification of a Hit-and-Run Automobile", Vol. 31, No. 1, 1986, pp. 329-32.

POSSIBLE RESULTS

TOOLMARK COMPARISONS

- Toolmarks found on Item XXX were made by the tool submitted Item XXX.
- In view of this identification, no further comparisons were made.
- Toolmarks present on Item XXX could neither be identified nor eliminated as having been made by the tool submitted Item XXX. ***
- Toolmarks found on Item XXX could not have been made by the tool submitted item XXX.
- Toolmarks found on Item XXX were not suitable for comparison.
- Toolmarks represented by the cast submitted Item XXX …

*** Within the category of no identification – no elimination there may be degrees of certainty expressed. No professional standard exists which limits an expression of likelihood. By ASCLD-LAB requirement, where no definitive conclusion can be reached, the report will clearly communicate the reason(s); e.g. insufficient agreement of individual characteristics, damage, etc.

PHYSICAL FITS

Five possible results can be made regarding physical fits. These include:

- The positive identification that two or more objects at one time formed a single object or were physically joined.
- The items were positively identified as having a common origin, but did not constitute a physical fit.
- The objects did not physically fit, but could at one time, have formed a single object. (Inconclusive)
- The objects could not be physically fit together, nor could they have had a common origin.
- The inconclusive result when no determination can be made, such as when items are not suitable for comparison.

Within category "3" there may be degrees of certainty expressed. No professional standard exists which limits an expression of likelihood. Procedure in reporting conclusions other than verifiable identifications or eliminations is discretionary. By ASCLD-LAB requirement, where no definitive conclusion can be reached, the report will clearly communicate the reason(s); e.g. insufficient agreement of individual characteristics, damage, etc.

Issue Date	History
3/31/00	Original Issue
1/30/04	Revised to add new Firearms Examiner Gene Rivera, updated interpretation section, updated process map.
3/28/08	Consolidated Toolmark and Physical Fit SOPs. No content changes made.
3/8/11	Updated Interpretation of Results and Reporting Inconclusives for ISO requirements. Added a note on instrumentation used by examiners and added Appendix D.
6/17/11	Updated footers for ISO 17025

Approval

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Issuance

Chief Criminalist _____ Date:
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