OSAC 2024-S-0002
Standard Test Method for the Examination and Comparison of Toolmarks for Source Attribution

Firearms & Toolmarks Subcommittee
Physics/Pattern Interpretation Scientific Area Committee
Organization of Scientific Area Committees (OSAC) for Forensic Science

OSAC Proposed Standard

OSAC 2024-S-0002
Standard Test Method for the Examination and Comparison of Toolmarks for Source Attribution

Prepared by
Firearms & Toolmarks Subcommittee
Version: 2.0
January 2025

Disclaimer:

This OSAC Proposed Standard was written by the Firearms & Toolmarks Subcommittee of the Organization of Scientific Area Committees (OSAC) for Forensic Science following a process that includes an open comment period. This Proposed Standard will be submitted to a standard developing organization and is subject to change.

There may be references in an OSAC Proposed Standard to other publications under development by OSAC. The information in the Proposed Standard, and underlying concepts and methodologies, may be used by the forensic science community before the completion of such companion publications.

Any identification of commercial equipment, instruments, or materials in the Proposed Standard is not a recommendation or endorsement by the U.S. Government and does not imply that the equipment, instruments, or materials are necessarily the best available for the purpose.

To be placed on the OSAC Registry, certain types of standards receive a Scientific and Technical Review (STR). The STR process is vital to OSAC's mission of generating and recognizing scientifically sound standards for producing and interpreting forensic science results. The STR shall provide critical and knowledgeable reviews of draft standards to ensure that the published methods that practitioners employ are scientifically valid, and the resulting claims are trustworthy.

The STR consists of an independent and diverse panel, which may include subject matter experts, human factors scientists, quality assurance personnel, and legal experts as applicable.

The selected group is tasked with evaluating the proposed standard based on a defined list of scientific, administrative, and quality assurance based criteria.

For more information about this important process, please visit our website at: https://www.nist.gov/organization-scientific-area-committees-forensic-science/scientific-technical-review-str-process

Foreword

This document is intended to provide standardized minimum requirements for the microscopic evaluation, classification, and comparison of toolmarks for source attribution and defines the minimum requirements for supporting documentation.

Additional documents which contain information related to this standards document include:

- Standard Scale of Source Conclusions and Criteria for Toolmark Examinations
- Standard for Verification of Source Conclusions in Toolmark Examinations
- OSAC Firearms Process Map

This document was developed to provide standardized minimum requirements for the microscopic comparison of toolmarks by forensic firearm and/or toolmark examiners for the purpose of source attribution.

Keywords: *Firearms, toolmarks, comparison, documentation, notes, photography*

Table of Contents

Standard Test Method for the Examination and Comparison of Toolmarks for Source Attribution

1 Scope

This standard provides procedures for the microscopic evaluation, classification, and comparison of toolmarks for source attribution and defines the minimum requirements for supporting documentation. Throughout this document, the term "toolmark" is used to refer to both firearm-produced and non-firearm-produced toolmarks.

2 Normative References

ANSI/ASB Standard 093, Sta*ndard Test Method for the Forensic Examination and Testing of Firearms*. 2020. 1st. Ed.

ANSI/ASB Standard 096, *Standard Method for the Examination and Documentation of Ammunition and Ammunition Components*. 2022. 1st. Ed.

ANSI/ASB Standard 100, *Standard Scale of Source Conclusions Criteria for Toolmark Examinations.* (Proposed OSAC Standard at SDO for Further Development and Publication)

ANSI/ASB Standard 162, *Standard for the Forensic Examination and Documentation of Non-firearm Tools and Non-firearm Toolmarks*. 2024. 1st. Ed.

3 Terms and Definitions

For the purposes of this document, the following definitions and abbreviations apply:

3.1
class characteristics
Observable features of a specimen which indicate a restricted group source. They result from design decisions made by a manufacturer that are within acceptable manufacturing tolerances and are, therefore, determined prior to manufacture.

3.2
classification
The determination of a specimen's discernible class characteristics, thereby defining the class to which it belongs (e.g., a .45 caliber bullet bearing five groove impressions and right twist).

3.3

comparison

The side-by-side examination of two toolmarks. This comparison may be performed microscopically or macroscopically, as needed.

3.4

conclusion (i.e., source conclusion)

Opinion stated by an examiner after interpretation of data observed when comparing toolmarks**.**

3.5

consultation

A discussion between the primary examiner and another qualified examiner for the purposes of providing guidance/opinion(s)/advice to the primary examiner pertaining to a source conclusion. This occurs prior to the source conclusion being reached by the primary examiner.

3.6

E3CV

Acronym for Evaluation, Classification, Comparison, Conclusion, Verification. A manner of describing the methodology employed by a Firearm and Toolmark Examiner when conducting a toolmark comparison for source attribution.

3.7

evaluation

The assessment of a specimen for features to determine its suitability for further classification and/or comparison.

3.8

examiner

The qualified firearm and toolmark examiner responsible for conducting a toolmark examination, reaching source conclusions, and authoring a report. This person may also be referred to as the "primary examiner" with regards to verifications.

3.9

exemplar

A toolmark produced by a known tool. Exemplars may also include a cast of a tool working surface. Exemplars are commonly referred to as "test marks" or, in the case of firearms, "test fires."

3.10

individual characteristics

Marks produced by the random imperfections or irregularities of tool surfaces. These random imperfections or irregularities are produced incidental to manufacture and/or caused by use, corrosion, or damage.

3.11

light comparison microscopy (LCM)

The use of connected optical microscopes to evaluate/compare microscopic features on two different specimens.

3.12

questioned toolmark

A toolmark produced by an unknown tool. Also sometimes referred to as an “unknown”.

3.13

subclass characteristics

Toolmarks produced by a single tool that repeat with little, if any, change on a limited series of sequentially manufactured items. These types of characteristics are not determined prior to manufacture, and are more restrictive than class characteristics (i.e., a subset of the class).

3.14

tool

The harder of two objects which, when brought into contact with each other, results in the softer object being marked by the harder object.

3.15

toolmark

A mark caused when a tool makes contact with an object.

3.16

verification

An independent comparison or analysis of items previously examined by the primary examiner to provide a quality check of value determinations or source conclusions.

3.17

verifier

The firearm and toolmark examiner tasked with reaching independent opinions or source conclusions regarding evidence previously examined by the primary examiner.

3.18

virtual comparison microscopy (VCM)
A practitioner's use of rendered images of 3D surface topography measurement data for visual comparison and evaluation.

4 Requirements

4.1 Background

A laboratory shall have procedures in place prior to beginning evaluations or comparisons of toolmarks. Comparisons may be performed between two or more questioned toolmarks, between two exemplars, or between exemplars and questioned toolmarks. Most toolmark comparison casework follows a general methodology of Evaluation, Classification, Comparison, Conclusion and Verification (E3CV).

4.2 Evaluation and Classification of Toolmarks or Known Tools

4.2.1 Evaluation

Each tool and/or toolmark shall be evaluated independently from other tools and/or toolmarks for the presence of discernible class characteristics, subclass characteristics, and individual characteristics that may assist in source conclusions.

4.2.1.1 If no class, no subclass, and no individual characteristics are discernable, the specimen has no value for classification or comparison. The specimen may be suitable for other analyses not addressed in this document.

4.2.1.2 If class, subclass, and/or individual characteristics are discernable, then the specimen may be suitable for further classification and/or comparison.

4.2.2 Classification

Document the relevant class characteristics of the tool or toolmark.

Class characteristics may include, but are not limited to:

4.2.2.1 Non-Firearm Tool/Toolmark Class Assessment

- Type of tool
- Tool action type
- Dimensions of tool working surfaces
- Dimensions of the toolmark
- Characterization of manufacturing process (e.g., impressed, striated, gross vs. fine markings, parallel vs. arches, etc.)
- Possible manufacturing processes employed (e.g., broaching, milling, bead blasting, casting)

4.2.2.2 Firearm Class Assessment

- Firearm type/operating system
- Caliber
- Characterization of manufacturing process (e.g., parallel breechface marks, concentric circles on firing pin, etc.)
- Possible manufacturing processes employed (e.g., broaching, milling, bead blasting, casting)
- Firing pin shape
- Firing pin aperture shape
- Location and shape of extractor and ejector
- Rifling characteristics (e.g., number of lands and grooves, dimensions of lands and grooves)
- Characterization of toolmarks within a barrel (e.g., longitudinal or circumferential toolmarks on lands and/or grooves, etc.)

4.2.2.3 Fired/Cycled Ammunition Component Class Assessment

4.2.2.3.1 Bullets

- Diameter/caliber
- Weight
- Number of land and groove impressions
- Direction of twist
- Land impression width
- Groove impression width
- Rifling profile (conventional or polygonal)

4.2.2.3.2 Cartridge Cases and Fired Shotshells

- Caliber/gauge
- Breech face marks (e.g., parallel, arced, granular, circular, cross-hatched)
- Location and shape of extractor and ejector marks
- Firing pin impression shape
- Firing pin aperture shape
- Feed/cycling marks

In some instances, it may not be possible to determine class characteristics due to the condition of the specimen under examination.

4.2.2.4 Comparison of Class Characteristics

If discernible class characteristics are in agreement, continue with further examination and comparison. If discernible class characteristics are in disagreement, a conclusion of exclusion shall be reached.

4.2.3 Subclass vs Individual Characteristic Assessment

Examine and evaluate the tool working surface(s) or the toolmark for subclass characteristic potential.

4.2.3.1 Evaluation of Tool

All surfaces used as a basis for a source conclusion other than a class exclusion shall be evaluated for the potential presence of subclass characteristics. The manufacturing method(s) and its potential for subclass characteristics shall be considered.

The following attributes may be indicative of the potential for subclass characteristics:

- Coarse/gross detail
- Mold marks/part lines
- Stamping marks
- Repeating pattern
- Marks that continue from one end of the working surface to the opposite end
- Uniform spacing of marks

The following non-exhaustive list of attributes are indicative of a working surface that contains or produces individual characteristics:

- A working surface that is the result of the intersection of two polished or machined surfaces (e.g., firing pin aperture edge)
- A machined working surface bearing a linear pattern that includes discontinuous and/or non-parallel features.
- A machined working surface bearing isolated features that are the result of random chip separation, chatter, etc.
- A working surface bearing features that are the result of hand filing, grinding, media blasting, tumbling, or other abrasive or burnishing finishing processes.
- A working surface bearing post-manufacturing defects from damage, use, corrosion, etc.
- A working surface bearing features that are the result of non-axial drilling, reaming, or honing processes (e.g., drilling/reaming marks on rifling lands, reaming marks in chamber, reaming marks in forcing cone)
- A working surface bearing features that are the result of electrochemical or electrical discharge machining (i.e., the presence of pitting on the work surface)

4.2.3.2 Evaluation of Toolmark

All surfaces used as a basis for a source conclusion other than a class exclusion shall be evaluated for the potential presence of subclass characteristics. When possible, assess the manufacturing method(s) and its potential for subclass characteristics.

The following attributes may be indicative of the potential for subclass characteristics:

- Coarse/gross detail
- Mold marks/part lines
- Repeating pattern
- Continuous, uninterrupted linear impressed marks
- Uniform spacing of marks

The following non-exhaustive list of attributes are indicative of individual characteristics:

- A toolmark that is the result of the intersection of two polished or machined surfaces (e.g., firing pin aperture shear)
- A toolmark bearing linear features that are discontinuous and/or non-parallel.
- A toolmark bearing isolated marks such as random chip separation, chatter, etc.
- Toolmarks that resulted from hand filing, grinding, media blasting, tumbling, or other abrasive or burnishing processes.
- Toolmarks bearing characteristics that are indicative of post-manufacturing defects such as damage, use, corrosion, etc.

4.2.3.3 A conclusion of same source shall not be based on agreement of potential subclass characteristics. Subclass characteristics indicate a restrictive group only.

4.3 Preparation of Exemplar (Test Marks)

Exemplars are produced from tools for comparison purposes. Exemplars may include toolmarks produced by a tool and/or casts of a tool working surface.

4.3.1 Preparation of Exemplars from Non-Firearm Tools

- Determine which working surface(s) or area(s) of the working surface of the tool may have been used. Consider physical constraints and the presence of trace materials that may indicate the area of the surface used.
- Select the appropriate test material, considering the relative hardness of the tool working surface and the test material so as to minimize damage to the tool working surface and successfully reproduce toolmarks for comparison. Typically, a softer material is initially selected; however, it may be necessary to select a harder material (e.g., progressing from lead to copper to steel) to obtain suitable exemplars for comparison.
- Attempt to determine and replicate the tool-substrate interaction that occurred when the questioned toolmark was created (e.g., angle, pressure, direction).
- Label exemplars in accordance with laboratory policy. If possible, the physical specimens should be directly marked with a unique identifier.
- As an alternative, or in addition, to producing toolmark exemplars, it may be desirable to produce casts of the tool working surface.
- In situations when the tool will be directly compared to the toolmark, the preparation of exemplars may not be necessary.
- Exemplars used for source conclusions shall be preserved, whether retained in the laboratory, returned to the submitting agency, or some other mechanism.

4.3.2 Preparation of Exemplars from Firearms

- Select appropriate ammunition for test firing. In order to minimize variables, the ammunition selected should be the same caliber, design, and composition as the specimens to be compared.
- Select an appropriate recovery medium that will minimize damage to any test-fired bullets.
- Conduct test firing.
- Label exemplars in accordance with laboratory policy. If possible, the physical specimens should be directly marked with a unique identifier.
- As an alternative, or addition to, producing test-fired exemplars, it may be desirable to produce casts of the firearm working surface(s).
- If the firearm is nonfunctional, exemplars of specific working surfaces may need to be created using a suitable medium (e.g., lead, silicone cast, etc.).
- In situations when the working surface will be directly compared to the toolmark, the preparation of exemplars may not be necessary.
- Exemplars used for source conclusions shall be preserved, whether retained in the laboratory, returned to the submitting agency, or some other mechanism.

4.4 Comparison of Microscopic Toolmarks

4.4.1 Microscopic Comparison

- Select the type of microscopic evaluation/comparison to be performed (e.g., Light Comparison Microscopy and/or Virtual Comparison Microscopy) in accordance with laboratory policy.
- Orient specimens for comparison.
- Use a systematic process to ensure the identity of the specimens being examined. The process shall include the confirmation of the unique identifiers of the specimens.
- Optimize magnification. A variety of magnification levels should be used when comparing toolmarks. Typically, lower magnification is used first and magnification may be increased as needed to observe relevant detail. The magnification should be the same for both specimens.[1]
- Optimize lighting. Oblique lighting is usually preferred. Lighting may be varied during the course of the examination.

4.4.2 Exemplar Comparisons

Exemplars produced by the suspected tool shall be microscopically intercompared to assess the reproducibility of toolmarks. This intercomparison should be conducted prior to the comparison to unknown.

Exemplars in varying substrates may be evaluated to determine the effects of the substrate on the toolmark.

[1] In situations of a distorted specimen compared to an undamaged one, minor adjustments to the magnification may be appropriate to account for distortion. If done, this shall be recorded in the case record.

If subclass marks are observed on the tool/firearm, then subclass influence shall be considered when comparing exemplars. Subclass on the tool/firearm does not necessarily preclude the use of that area for source conclusion. The interaction between the working surface and the item being marked influences whether subclass marks on the tool/firearm are directly transferred or if the resulting toolmark has no subclass influence. Comparing the toolmarks on the tool/firearm to the resulting toolmark(s) on the exemplar can assist with this assessment. Potential subclass characteristics within a toolmark shall not be used as the basis for an identification conclusion.

4.4.3 Questioned Toolmark Comparisons

Comparison may be performed between two or more questioned toolmarks (for common source), or between exemplars and questioned toolmarks (for specific source).

Compare areas of interest and document the specific areas (e.g., breech face, firing pin) and any significant agreement and/or disagreement observed.

The entirety of the toolmark or combination of toolmarks shall be considered. Examiners shall consider all similarities and differences observed prior to reaching a conclusion.

During the comparison process the following factors may also be considered:

- Need for additional exemplars
- Enhancement techniques (e.g., magnesium fuming, cast of deep firing pin impression)
- Consultation with another examiner(s)

4.5 Conclusion

SEE CONCLUSIONS DOCUMENT

4.6 Verification

SEE VERIFICATION DOCUMENT

4.7 Documentation

The evaluation, classification, subclass characteristic assessment, and comparison shall be documented. Documentation shall include depictions or descriptions of the observations to the extent that another examiner, without the benefit of the specimens themselves, can review the case record and understand what analysis was conducted, and the basis for any conclusions. All documentation shall be retained per laboratory policy.

4.7.1 Documentation of Evaluations that result in a determination of “no value” for comparison shall include the basis for that determination (e.g., no class or individual characteristics present).

- Written notes are sufficient and may be supplemented with photographs.

- Determinations of value are implied to be "of value" if the examiner moves on to further classification/comparison, and thus do not need to be explicitly stated/documented.
- If it is determined an item is of value for further comparison but is not further classified and/or compared (i.e., no other samples for comparison), the "of value" determination and the reason for no further analysis shall be documented.

4.7.2 Documentation of Classification examinations shall include:

- The relevant class characteristics of each item.
- If certain class characteristics cannot be determined (e.g., a bullet fragment, partial toolmark), the documentation shall include the reason(s).
    - If a range of classes can be determined, the documentation shall include reasons for the determination.
- Written notes are sufficient and may be supplemented with photographs.

4.7.3 Documentation of Subclass characteristic assessment shall include:

- The surfaces that were assessed for subclass and the observations that support the conclusions drawn from that assessment.
- The method of assessment, such as the microscopic assessment of the tool, use of casts, borescope, etc.
- Written notes are sufficient and may be supplemented with photographs.

4.7.4 Documentation of Comparison examination shall include:

- **Exemplars:** areas of the specimens compared and observations.
- **Questioned toolmarks:** areas of the specimens compared, observations, and conclusion(s) reached.
    - **Same-source conclusions:** photographic documentation with supplemental descriptions of the agreement of individual and/or class characteristics. If multiple toolmarks on a specimen are used for a same-source conclusion (e.g., firing pin *and* breech face), each mark shall have photographic documentation.
    - **Inconclusive conclusions**: descriptions of agreement/disagreement or absence of individual and/or class characteristics. These descriptions may be supplemented with photographic documentation .
    - **Different-source conclusions**: Descriptions of the disagreement of individual and/or class characteristics. These descriptions may be supplemented with photographs. If a different-source conclusion is based on differences of individual characteristics, photographic documentation shall be included.

4.7.4.1 While it is recognized that photographic documentation (e.g., photographs, VCM screenshot) cannot be held in equal standing with live comparison observations, photographs shall, to the extent possible, document the observations that formed the basis for the reported conclusions.

4.7.4.2 It shall be clear from the documentation which pair-wise comparisons were performed, as well as any additional measures taken (e.g., enhancement techniques, need for additional

exemplars), so that another examiner can perform the same pair-wise comparisons under similar conditions. The documentation shall include which specific exemplar(s) was used, when applicable.

4.7.4.3 A statement of conclusion alone, without supporting documentation, is insufficient.

4.7.4.4 A photograph(s) of one comparison may be used as documentation for multiple comparisons as long as what is depicted in the image(s) is representative of the toolmark(s) and level of agreement observed in all comparisons.

Appendix A

(Informative)

Bibliography

1) ANSI/ASB Best Practice Recommendation 068, Safe *Handling of Firearms and Ammunition.* 2020. 1st. Ed.

2) ANSI/ASB Standard 093, *Standard Test Method for the Forensic Examination and Testing of Firearms.* 2020. 1st. Ed.

3) Nichols R., "Subclass Characteristics: From Origin to Evaluation" *AFTE Journal.* Spring, 2018. 50(2) pages 68-88.