Technical Procedure for Tool Mark Examination

1.0 Purpose – To outline the procedures for examination and comparison of tool mark evidence.

2.0 Scope – This procedure applies to cases submitted to the Firearm and Tool Mark Section that contain tool marks.

3.0 Definitions

- **Class characteristics** – Measurable features of a specimen which indicate a restricted group source. They result from design factors, and are therefore determined prior to manufacture.
- **Comparison microscope** – Essentially two microscopes connected by an optical bridge which allow the viewer to observe two objects simultaneously with the same degree of magnification**.**
- **Extrusion mark** – Striations occurring on an object which were produced by being forced through a die. They are commonly found on wire and are sometimes called draw marks.
- **Fracture match** – The examination of two or more objects which permits one to conclude whether the objects were either one entity or were held or bonded together in a unique arrangement.
- **Gripping Tool** - A tool with opposing jaws such as a pipe wrench, pliers, vise, etc.
- **Impressed tool mark** – Surface contour variations that result from a tool applied to an object with force but without motion, or where the motion is approximately perpendicular to the plane being marked.
- **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. They are unique to that tool and distinguish it from all other tools.
- **Objective** – The lens or lenses in an optical instrument which form the image of an object.
- **Oblique lighting** – A method of illumination where the light source is placed at an angle, generally to produce shadows or enhance edges.
- **Pinching tool** - A tool with sharpened opposing jaws which cut with a pinching action, such as a pair of bolt cutters.
- **Prying tool** - Any instrument which is or can be used to force open a locked door or cover by leverage applied to that door or cover at one of its edges.
- **Shear cutting tool** - Opposed jawed cutters whose cutting blades are offset to pass by each other in the cutting process, i.e., tin snips or scissors.
- **Striated tool mark** – Surface contour variations, generally microscopic, that result from a tool applied to an object with a combination of force and motion where the motion is approximately parallel to the plane being marked.
- **Sufficient agreement** – Agreement is sufficient when it exceeds the best agreement demonstrated between tool marks known to have been produced by different tools and is consistent with the agreement demonstrated by tool marks known to have been produced by the same tool.
- **Tool** - An object used to gain mechanical advantage. Also, the harder of two objects which when brought into contact with each other, results in the softer one being marked.

4.0 Equipment, Materials, and Reagents

- Comparison microscope
- Stereomicroscope
- Caliper
- Tape measure

- Engraver
- Test materials (e.g., sheet lead, sheet copper, copper wire, lead bullets, wax, etc.)
- Mikrosil
- Forensic Sil
- Cotton-tipped swabs
- Cleaning solutions such as Terg-A-Zyme, Hibiclens, ethanol, and acetone
- Personal protective equipment
- Soft bristle brush

5.0 Procedure

5.1 Tool Examination

5.1.1 Item Preparation

5.1.1.1 Tool mark cases without a suspect or where the tool cannot be linked to an individual shall not be analyzed. Any exception to this policy must be requested in writing by the appropriate District Attorney, US Attorney, Judicial Official, or Federal/State Official and approved by the Section Forensic Scientist Manager or higher ranking State Crime Laboratory authority.

5.1.1.2 Prior to examination, ensure that any additional service requests (e.g., Forensic Biology, Trace, Latent, etc.) that should be completed before analysis by the Firearm and Tool Mark Section have been so completed. This can be verified by examining one, or a combination, of the following:

5.1.1.2.1 The status of other case records in Forensic Advantage (FA).

5.1.1.2.2 The chain of custody.

5.1.1.2.3 Markings from other Forensic Scientists on the evidence packaging.

5.1.1.3 Wear appropriate personal protective equipment, such as gloves, lab coat, and/or safety glasses, if the item may be contaminated with a biohazardous material (blood or other potentially infectious material).

5.1.1.4 Visually inspect the item for possible trace evidence such as hair, fibers, wood, etc. Note the location on the item where the trace material was found. Carefully remove the material and place in a container suitable for return to the submitting agency or submission to the appropriate Laboratory Section for further examination.

5.1.1.4.1 If the trace material is not to be retained, indicate as such in the case notes.

5.1.1.5 Tools that are contaminated with blood, body matter or other biological material shall be cleaned with a soft bristle brush and a disinfectant such as Terg-A-Zyme, Hibiclens, and/or ethanol.

5.1.1.6 Tools may generally be cleaned with a cotton-tipped swab saturated with ethanol or acetone.

5.1.1.7 Mark all evidence tools for identification.

5.1.1.7.1 Mark away from the working edge(s).

5.1.1.7.2 Mark with the item designation number (K number), the Laboratory case number, and the Forensic Scientist's initials.

5.1.2 Physical Characteristics Examination

5.1.2.1 A separate Tool Mark Worksheet shall be filled out in FA for each evidence tool. Each worksheet shall contain the item designation number (K number) assigned to the item by the Forensic Scientist.

5.1.2.1.1 Physical features of tools that shall be noted, if applicable, include:

- Manufacturer
- Type of tool (prying, gripping, pinching, shearing, etc.)
- Serial number
- Size
- Type, color, and condition of the tool's finish
- Areas of use or wear on the tool
- Tool dimensions:
  - Overall length
  - Length of blades
  - Size of bar stock
  - Width and thickness of prying tips/working ends
  - Diameter of head of hammer or similar impact tools
  - Size of jaws
  - Number of teeth and distance between teeth
- Any irregularities in the working end:
  - Broken or missing tips
  - Deep indentations in the working end
  - Bright or shiny areas where dust, corrosion, or new paint has been removed
  - Blades out of alignment
- Trace evidence on the working end, such as paint chips (the presence of trace material may be an indication of which part of the tool was used to make the questioned tool mark)

5.1.2.1.2 A sketch or photograph of the tool may be made to assist the Forensic Scientist in describing the tool.

5.2 Fracture Match Protocol

5.2.1 Initial Examination

5.2.1.1 Physical features of the potentially separated items that may be noted include:

- Coatings
- Method of separation
- Composition
- Color
- Dimensions of the items
- Pattern
- Appearance and/or distortion of the separated edges
- Trace material

5.2.2 Visual/Microscopic Comparison

5.2.2.1 Determine if the items may be physically oriented with one another.

5.2.2.2 Microscopically examine the oriented edges looking for the presence of corresponding irregularities.

5.2.2.2.1 Attempt to align the fracture marks present on the tip/blade to those on the broken tip/blade of the tool.

5.2.2.2.2 Attempt to align any extrusion marks in the metal of the tip/blade and the tool.

5.2.2.2.3 Attempt to align any other individual marks that may be present on the tip/blade and the tool near the broken tip/blade.

5.2.2.2.4 A cast of one of the separated edges may be made for comparison with the other separated edge.

5.2.2.3 Based on the microscopic evaluation of the objects, determine whether or not sufficient microscopic correspondence exists between the items to identify them as having been joined at one time as one unit.

5.3 Tool Mark Examination

5.3.1 Item Preparation

5.3.1.1 Prior to examination, ensure that any additional service requests (e.g., Forensic Biology, Trace, Latent, etc.) that shall be completed before analysis by the Firearm and Tool Mark Section have been completed. This may be verified by examining one, or a combination, of the following:

5.3.1.1.1 The status of other case records.

5.3.1.1.2 The chain of custody.

5.3.1.1.3 Markings from other Forensic Scientists on the evidence packaging.

5.3.1.2 Wear appropriate personal protective equipment, such as gloves, lab coat, and/or safety glasses, if the item may be contaminated with a biohazardous material (blood or other potentially infectious material).

5.3.1.3 Visually inspect the item for possible trace evidence such as hair, fibers, wood, etc. Note the location on the item where the trace material was found. Carefully remove the material and place in a container suitable for return to the submitting agency or submission to the appropriate Laboratory Section for further examination.

5.3.1.3.1 If the trace material is not to be retained, indicate as such in the case notes.

5.3.1.4 Items containing tool marks contaminated with blood, body matter or other biological material shall be cleaned with a soft bristle brush and a disinfectant such as Terg-A-Zyme, Hibiclens, and/or ethanol.

5.3.1.5 Items containing tool marks may generally be cleaned with a cotton-tipped swab saturated with ethanol or acetone.

5.3.1.6 Mark all items that have been tool marked for identification.

5.3.1.6.1 Mark the item in an area away from any tool marks.

5.3.1.6.2 Mark with the item designation number (Q or K number, as appropriate), the Laboratory case number, and the Forensic Scientist's initials.

5.3.2 Physical Characteristics Examination

5.3.2.1 A separate Tool Mark Worksheet shall be filled out in FA for each evidence tool mark. Each worksheet shall contain the item designation number (Q or K number, as appropriate) assigned to the item by the Forensic Scientist.

5.3.2.1.1 Physical features of a tool mark that shall be noted, if applicable, include:

- Description of the item containing the tool mark:
  - Manufacturer
  - Composition
  - Color
  - Finish
  - Position of the tool mark on the item
- Type of tool mark (impressed, striated, or both)
- Width or diameter of the tool mark
- Number of teeth marks and distance between them
- Type of cutting motion employed by the tool
- Any marked irregularities:
  - Any striations much deeper than others

Jagged, rough edge that may indicate missing or fractured tool tip

- Direction of motion of the tool that created the mark
- Angle of the tool when it created the mark
- Trace evidence on or near the tool mark, such as paint chips (the presence of trace material may be an indication of which part of the tool was used to make the questioned tool mark)

5.3.2.1.2 A sketch or photograph of the tool mark may be made to assist the Forensic Scientist in describing the mark.

5.3.2.2 Based on the Forensic Scientist's training and experience, the scientist may remove the tool mark from the item to facilitate microscopic examination and comparison.

5.3.2.2.1 If wire or chain link is cut, the Forensic Scientist shall mark the ends that he/she made with a dark marker and record the information in the case notes.

5.3.2.2.2 If it is not possible to remove the tool mark from a large item or if removing the tool mark would damage or mar the mark, a cast shall be made of the tool mark.

5.3.2.3 If the class characteristics of the tool mark are markedly different from the tool, no further examination is necessary. The Forensic Scientist may conclude that the tool did not make the tool mark.

5.4 Comparison Microscope Protocol

5.4.1 The following is an illustration of an approved method of performing a comparison microscope examination of test and/or evidence tool marks. Forensic Scientists may develop an individual routine for this type of examination; however, they shall incorporate the general underlined points mentioned below.

5.4.1.1 Production of test tool marks

5.4.1.1.1 Initially, the media used to make test tool marks shall be softer (such as lead, copper, etc.) than the surface of the item marked to prevent alterations of the tool's working surface. It may be necessary later to make more test marks in a material similar to or the same as the item upon which the questioned mark was found. At times, a portion of the evidence may be required to conduct the test.

5.4.1.1.2 Use the information gleaned from examinations of the tool and questioned tool mark to produce test marks if applicable.

5.4.1.1.2.1 If some determination was made as to the area of the tool that may have contacted the item, primary emphasis may be placed on tests made by this area.

5.4.1.1.2.2 If examination of the tool and tool mark does not indicate which area of the tool may have been used, tests shall be made using all possible areas of the tool's working end/working parts.

5.4.1.1.3 When making striated test marks, the Forensic Scientist shall attempt to reproduce the vertical and horizontal angles at which the questioned tool mark was made.

5.4.1.1.3.1 If these angles cannot be determined, it is generally best to change continuously both the vertical and horizontal angle of the tool in relation to the surface of the medium being marked as the tests are made.

5.4.1.1.4 If silicone/rubber casts were made of the questioned tool mark, then silicone/rubber casts shall be made of the test tool marks for comparison purposes.

5.4.1.2 Select the correct objective (magnification) setting and ensure that the objectives are locked in place. Low magnification (10X – 15X) is typically used to examine the tool mark looking for a position that best highlights the individual characteristics on the tool mark. Higher magnification (20X or greater) is typically used to verify the correspondence of finer striations.

5.4.1.3 The illumination (lights) used shall be properly adjusted. Oblique lighting is usually preferred.

5.4.1.4 If a tool was submitted for comparison to a questioned tool mark, first compare the test tool marks to each other to determine what microscopic characteristics are reproducing.

5.4.1.4.1 If the test tool marks cannot be matched to each other (there is not sufficient agreement), more tests marks may be made and inter-compared. If the test tool marks still cannot be matched, the Forensic Scientist may reach the conclusion that the tool in question does not reproduce its individual characteristics very well or that the tool does not produce sufficient individual marks to reach a positive conclusion.

5.4.1.5 Compare a questioned tool mark to either another questioned tool mark or a test tool mark.

5.4.1.5.1 The Forensic Scientist can ascertain at this point if the class characteristics agree.

5.4.1.5.1.1 If the class characteristics are markedly different and this difference is not attributed to deformity or damage to the tool after the creation of the questioned mark, the Forensic Scientist may conclude that the evidence mark

was not created by the evidence tool or that the questioned marks were not created by the same tool.

5.4.1.5.2 These examinations shall be made with the tool marks in phase. This means that the tool marks that are being examined shall be oriented similarly using a common point of reference.

5.4.1.6 Manipulate the stages to move the tool marks and attempt to align any impressions/striations that are present.

5.4.1.7 The entire unknown shall be considered.

5.4.1.8 If the tool marks may be matched to each other, the marks shall be indexed with an indelible marker to indicate the position in which the agreement is most clearly viewed.

5.4.1.8.1 The Forensic Scientist may refer to previously indexed areas when describing the orientation.

5.4.1.9 If an identification is not initially made, the Forensic Scientist may consider the following possible reasons for the lack of sufficient agreement:

5.4.1.9.1 The questioned tool mark and test tool marks were created by different tools.

5.4.1.9.2 The tool was damaged between creating the questioned tool mark and the test tool mark.

5.4.1.9.3 The test material available is significantly different from the evidence causing a difference in the way the tool marks the surface.

5.4.1.9.4 Damage occurred to the questioned tool mark causing distortion, deformation or the elimination of microscopic detail.

5.4.1.9.5 Other reasons may exist and may be considered and tested if appropriate at the discretion of the Forensic Scientist based on his/her training and experience.

5.5 Range of Conclusions

5.5.1 The suggested report wording listed below may be modified at the Forensic Scientist's discretion to reflect more accurately his/her conclusions. Any such modifications to report wording shall be reviewed and approved with the technical review.

5.5.2 Identification

5.5.2.1 There is agreement of all discernible class characteristics and sufficient agreement of individual characteristics to constitute a match.

- "The Q-1 tool mark was produced by the K-1 tool."

- "The Q-1 and Q-2 tool marks were produced by the same tool."
- "The Q-1 broken tip/blade was at one time part of the K-1 tool."

5.5.3 Inconclusive

5.5.3.1 There is agreement of all discernible class characteristics and some agreement of individual characteristics, but insufficient for an identification.

- "There is agreement of all discernible class characteristics and some agreement of individual characteristics between the Q-1 tool mark and test marks produced by the K-1 tool. However, the agreement is insufficient to identify Q-1 as having been produced by the K-1 tool."
- "There is agreement of all discernible class characteristics and some agreement of individual characteristics between the Q-1 and Q-2 tool marks. However, the agreement is insufficient to identify Q-1 and Q-2 as having been produced by the same tool."
- "There is agreement of all discernible class characteristics and some agreement of individual characteristics between the Q-1 broken tip/blade and the K-1 tool. However, the agreement is insufficient to identify Q-1 as having been at one time part of the K-1 tool."

5.5.3.2 There is agreement of all discernible class characteristics without agreement or disagreement of individual characteristics due to an absence, insufficiency, or lack of reproducibility.

- "There is agreement of all discernible class characteristics without agreement or disagreement of individual characteristics between the Q-1 tool mark and test marks produced by the K-1 tool due to an absence, insufficiency, or lack of reproducibility. Therefore, it cannot be determined whether or not Q-1 was produced by the K-1 tool."
- "There is agreement of all discernible class characteristics without agreement or disagreement of individual characteristics between the Q-1 and Q-2 tool marks due to an absence, insufficiency, or lack of reproducibility. Therefore, it cannot be determined whether or not Q-1 and Q-2 were produced by the same tool."
- "There is agreement of all discernible class characteristics without agreement or disagreement of individual characteristics between the Q-1 broken tip/blade and the K-1 tool. Therefore, it cannot be determined whether or not Q-1 was at one time part of the K-1 tool."

5.5.3.3 There is agreement of all discernible class characteristics and disagreement of individual characteristics, but insufficient for elimination.

- "There is agreement of all discernible class characteristics and disagreement of individual characteristics between the Q-1 tool mark and test marks produced by the K-1 tool. However, the disagreement is insufficient to eliminate Q-1 as having been produced by the K-1 tool."

- "There is agreement of all discernible class characteristics and disagreement of individual characteristics between the Q-1 and Q-2 tool marks. However, the disagreement is insufficient to eliminate Q-1 and Q-2 as having been produced by the same tool."

- "There is agreement of all discernible class characteristics and disagreement of individual characteristics between the Q-1 broken tip/blade and the K-1 tool. However, the disagreement is insufficient to eliminate Q-1 as having been at one time part of the K-1 tool."

5.5.4 Elimination

5.5.4.1 There is significant disagreement of discernible class characteristics and/or individual characteristics.

- "The Q-1 tool mark was not produced by the K-1 tool."

- "The Q-1 and Q-2 tool marks were not produced the same tool."

- "The Q-1 broken tool tip/blade was not at one time part of the K-1 tool."

5.5.5 Unsuitable

5.5.5.1 The tool mark evidence in question is not suitable for comparison purposes.

- "There were no tool marks present on the K-1 chain."

5.5.6 Forensic Scientists shall include in their notes all conclusions reached from the microscopic comparison of tool marks and/or test tool marks. Forensic Scientists shall also explain the reasons for reaching these conclusions. The reasons shall be clear and succinct and shall be able to be understood by any other competent forensic tool mark scientist. The Forensic Scientist shall include the position and type of index marks used and which of the test marks was used or if more than one test was used to reach the conclusions.

5.6 Standards and Controls – N/A

5.7 Calibration – For caliper and tape measure calibration information, see the Firearm and Tool Mark Section Technical Procedure for Instrument Calibration and Maintenance.

5.8 Maintenance – For comparison microscope, stereomicroscope, caliper, and tape measure maintenance, see the Firearm and Tool Mark Section Technical Procedure for Instrument Calibration and Maintenance.

5.9 Sampling – N/A

5.10 Calculations – N/A

5.11 Uncertainty of Measurement – N/A

6.0 Limitations – N/A

7.0 Safety – Examinations performed in the Firearm and Tool Mark Section are inherently dangerous. These procedures involve hazardous chemicals, firearms, and power tools. All hazardous procedures shall be performed in compliance with the State Crime Laboratory Safety Manual. If the examination involves a biohazard, the Forensic Scientist shall use proper personal protective equipment, such as eye protection, a lab coat, and/or gloves.

8.0 References

The Association of Firearm and Tool Mark Examiners. The Association of Firearm and Tool Mark Examiners. Web. 14 Dec. 2011. <www.afte.org>

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Barber, D.C. and F.H. Cassidy. "A New Dimension with 'Mikrosil' Casting Material." *AFTE Journal* Summer 1987: 328.

DeForest, Gaensslen, and Lee. *Forensic Science: An Introduction to Criminalistics*. New York: McGraw Hill, 1983.

Stoner, D., and I. Zeldes. Federal Bureau of Investigation. "An Aid in Accident Investigation." *FBI Law Enforcement Bulletin* Mar. 1980: 11.

9.0 Records

- FA Worksheets: Main, Toolmark, and Disposition/Result

10.0 Attachments – N/A

Revision History		
Effective Date	Version Number	Reason
09/17/2012	1	Original Document
02/15/2013	2	Removed Raleigh from the header; 4.0 – added Forensic Sil