General Examinations

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1 INTRODUCTION

This procedure is for the documentation, evaluation, preparation, and examination of evidentiary items. It is utilized to determine whether a specimen may be physically consistent with an item, reference sample, or test item based on the class and/or physical characteristics. This procedure establishes the requirements for calibration, performance checks, and maintenance of equipment to ensure the accuracy and reliability of measurement results that have an impact on the quality of an examination.

2 SCOPE

This procedure applies to Firearms/Toolmarks Discipline (FTD) personnel or authorized personnel when conducting forensic examinations in the FTD. The FTD is composed of personnel from the Firearms/Toolmarks Unit (FTU) and the Scientific and Biometrics Analysis Unit-Toolmark Group (SBAU-TG).

3 EQUIPMENT

- Equipment
    - 3D toolmark topographical instruments
    - Alicona® Infinite Focus (IF) and G5 microscope
    - Alicona®-IF Verification tools
    - Alicona®-IF Calibration tools
    - Balance – 10-pound (lb.) capacity
    - Balances (measurement within ± 1 grain/~ 0.065 grams)
    - Bullet recovery/test firing device/system
    - Calipers (measurement within ± 0.001 in/0.01mm)
    - Camera
    - Computer
    - GelSight/Cadre TopMatch® Instrument
    - GelSight/Cadre TopMatch® calibration tools
    - GelSight Instrument
    - Measurement equipment
    - Measuring reticle
    - Microscope (stereozoom/comparison)
    - Micrometers (measurement within ± 0.001 in/0.01mm)
    - Reference standards
        - National Institute of Standards and Technology (NIST) traceable gauge blocks
        - NIST Standard cartridge case
        - NIST Standard bullet
    - NIST traceable steel rulers
    - NIST traceable weights
    - Stage micrometer

    - Weights
- Material
    - Casting material
    - Cleaning solvent
    - General laboratory supplies
    - Known exemplars
    - Metal scribe/marker
    - Modeling clay or equivalent
    - Non-abrasive cleaning tools
    - Personal protective equipment (PPE)
    - Test media (e.g., lead, brass, copper)
    - Pressurized air source

4 STANDARDS AND CONTROLS

- Known exemplars produced from evidentiary items during examination and reference materials serve as controls. Exemplars produced from the known item will be treated as secondary evidence in accordance with the FTD-121. Exemplars may include bullets and/or cartridge cases (test fires) produced by a known firearm, toolmarks produced by a known tool, and/or casts collected from a toolmarked item. When available, the following reference collections may be used:
    - Reference Firearms Collection
    - Reference Ammunition File
    - General Rifling Characteristics database
    - Other Government Agency databases
    - Manufacturer's catalogues/literature
    - Purchased databases
    - Published literature
    - Open-source information (e.g., AFTE Resources)

4.1 Equipment Standards and Controls

All equipment having an effect of the quality of an examination is properly maintained per manufacturer's guidelines and calibrated. The FTD ensures that equipment used for measurement can perform as recommended to provide an accurate result.

A. Prior to being placed into service, and when necessary, equipment that has a direct effect on the quality of an examination is calibrated and/or performance checked to verify that it meets any specifications required by the method.
B. Personnel in the FTD will handle and operate equipment in accordance with manufacturer's guidelines. Equipment and standards are properly stored when not in use to prevent contamination and damage.
    1. Equipment or standards that leave the control of the laboratory are properly packaged, inspected and performance checked and/or recalibrated upon their return.

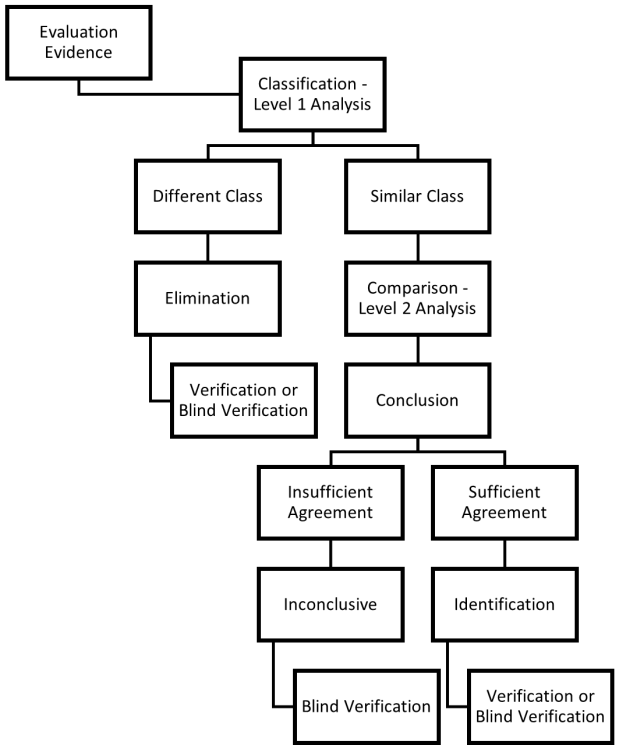
C. Due to differences in instrument resolutions, variations from manufacturer's guidelines exist as to how the instruments can be utilized (e.g., camera settings, lenses, calibration standards, etc.).
    1. Personnel in the FTD are not qualified or authorized to make adjustments to calibrated equipment and are prohibited from doing so.
D. Damage or changes to equipment or NIST traceable standards will be recorded by written notification to the Calibration and Maintenance Administrator (CMA) of the laboratory/location. The CMA will follow the LAB-100.
    1. A copy of the notification will be maintained by the CMA.
    2. The CMA will ensure that the replacement item is acquired as soon as practicable and will follow the LAB-100 to place the new item into service.
E. Microscopes are serviced by an evaluated vendor to ensure proper functioning, and to prevent contamination and deterioration.

5 SAMPLING

A. Statistical sampling is not applicable in the FTD.
B. Non-Statistical sampling is employed in the FTD. It is based on the training, experience and competence of the examiner. No assumptions are made regarding items/portions that were not selected for examination and Results of Examination in Laboratory Reports are specific to the items/portions that were examined.

6 METHODOLOGY

The methodology utilized by the FTD is Evaluation, Classification, Comparison, Conclusion and Verification (E3CV).



- Evaluation pertains to inspecting an item of evidence to determine if the evidentiary item is applicable for firearms/toolmarks examination. If an item can produce or contain an observable toolmark, the examination proceeds to Level 1 Analysis (Classification).
- Classification is the Level 1 analysis involving the assessment of the evidence for class characteristics through a series of measurements and/or observations. If there is a disagreement in class characteristics, an elimination conclusion can be rendered at this stage of the methodology. Additionally, classification involves the evaluation of microscopic marks (e.g., microscopic marks of value, limited microscopic marks of value, no microscopic marks of value). If class characteristics are in agreement, the examination proceeds to part one of the Level 2 Analysis (Comparison).
- Comparison is part one of the Level 2 analysis involving the side-by-side comparison of the individual characteristics for quality/quantity of agreement in their relative height or depth, width, curvature and spatial relationship of the individual peaks, ridges, and furrows within one set of surface contours compared to the corresponding features in the second set of surface contours.
- Conclusion is part two of the Level 2 analysis. At this stage, the Examiner will determine if sufficient agreement of individual characteristics exists to conclude a common source (Identification). If sufficient agreement of individual characteristics does not exist, an inconclusive determination may be opined.
- Verification pertains to the practice where a second Examiner (verifier) separately conducts the comparison and conclusion stages of examination. The option for a blind verification can also be utilized during this stage of the methodology.

7 PROCEDURE

7.1 Evaluation (Documentation and Preparation of Evidentiary Items)

7.1.1 Evidence Inventory

A. Ensure that the item and/or container has been properly labeled with the appropriate identifier.
B. The person inventorying the item for further examination will begin recording details in the appropriate FTD Worksheets.
    1. Non-evidentiary items will be inventoried, transferred appropriately, but will not be described in FTD Worksheets.
C. Observations regarding the condition of the item and/or packaging will be recorded in the appropriate FTD Worksheets.

7.1.2 Labeling Evidentiary Items

A. Ensure the item is labeled with the appropriate item identifiers. Examples include:
    - Metal scribe used to etch identifiers onto a surface that does not interfere with areas of interest.

- Marker used to label identifiers onto a surface that does not interfere with areas of interest.
- A tag, labeled with the identifiers, is attached to the item.
- A container, labeled with the identifiers, used to preserve the item.

B. Ensure the electronic evidence, when printed or copied, is labeled with the appropriate item identifiers.

7.1.3 Creating Case Notes

A. Depending on the evaluation of physical characteristics of an item, an FTD Worksheet will be started.
   1. Quick Parts within MS Word can be used to populate the fields within the FTD Worksheet.

B. The minimum required fields will be included in the completed FTD Worksheet:
   - Description of packaging
   - Name of preparer(s)
   - Item Identifier
   - Start and end dates of examinations
   - Laboratory number
   a. Completed FTD Worksheets will contain information for all applicable categories for the appropriate examination type per the defined fields in the FTD-001.

C. When trace evidence is observed and determined to be of probative value, the Examiner will coordinate the removal and/or preservation of the material.
   a. If no trace evidence is observed or has no probative value, the item can be cleaned in preparation for examination in accordance with section 7.1.5.

D. If an FTD Worksheet is not available for creating case notes, an alternative method can be utilized and will include the minimum requirements for collecting supporting examination records.

7.1.4 Photographing Evidentiary Items

A. Photographs may be added to the FTD Worksheets.

B. Prior to cleaning an item, a photograph should be collected of the evidence being examined.

C. Photographs that are printed as an attachment to FTD Worksheets or incorporated into the case file 1A will meet the requirements in section 2.10.B of the Operations Manual.

7.1.5 Cleaning Evidentiary Items

A. Cleaning an item of debris or biohazard material can be done using the following methods:
   - Cloth or cotton swab to loosen debris
   - Non-abrasive cleaning tool, brush or wooden toothpick to loosen debris
   - Cleaning solvent, such as water, alcohol or acetone can be used to remove paint and other debris.

- For corrosion or heavily stained items, CLR™ or an equivalent cleaner can be used to facilitate the restoration of the original surface.
    - Note: Due to the deleterious effects of prolonged exposure of metal to this type of cleaner, this method should be used as a last resort and/or monitored.
    - Wire brushes or other abrasive materials should not be used to clean the area as these items can alter the surface features.

B. A cleaning technique that was used can be described in the appropriate FTD Worksheets.
C. Following cleaning, it may be necessary to acquire additional photographs of the items or surfaces being examined.

7.1.6 Casting of Marked Surfaces

A. It may be necessary to cast any marked surfaces present on an evidentiary item(s) for the evaluation and preservation for comparisons.
B. Prior to casting, thoroughly examine the marked surfaces and make specific notations of what is observed, to include any trace material. This can include taking measurements of characters, known items or marked surfaces.
    1. Measurements will be recorded in accordance with sections 7.2.1 and 7.2.2.
    2. Treat each marked surface area independently and record accordingly.
C. If an item contains multiple areas for casting, those areas should be labeled appropriately and visible in the photographs.
D. Casting material may be tested on an inconspicuous area of the item to ensure:
    - Casting material performs/replicates the casted substrate/item.
    - Casting material does not alter the item.
E. If necessary, build a dam around the area of interest using modeling clay or suitable substrate. The dam should be constructed to retain the casting material in place until it has fully hardened.
F. Place casting material into the dam and allow time to harden. Casts may set at varying times depending on multiple factors. Variables such as temperature may result in prolonged cast curing time. Casting materials designed to be used within a specific temperature range should be used if possible.
    1. Identifiers may be placed on the substrate to become a permanent part of the cast, or a paper label may be placed in the back of the cast.
G. Once the cast has fully set, remove the clay dam, and remove the cast. Examine the cast for deposits of any debris that might have been missed during the cleaning process.
    1. It may be necessary to make multiple casts of each area to remove debris and capture the microscopic detail and to facilitate undistorted comparisons.
H. Retained cast material is considered secondary evidence.
    1. It is at the discretion of the examiner as to whether damaged or incomplete casts are retained.

7.1.7 Generating Secondary Evidence

Secondary evidence in the FTD is defined in section 3.4 of FTD-121.

7.1.7.1 Marking Secondary Evidence

A. FTD secondary evidence will be labeled, at a minimum, with the following:
    1. Item identifier associated with the primary item, preceded by an '*f* ' (meaning from), e.g., Item 4 screwdriver – test marks produced from Item 4 will be marked *f* Item 4 or *f* I4.
    2. Laboratory Number
    3. Initials
B. For FTD secondary evidence scanned for VCM, items will be labeled, at a minimum, with the following:
    1. Item identifier associated with the primary item, preceded by an 'f '
    2. Laboratory number
    3. Initials
    4. Unique identifier for test fires utilized for instrument acquisition (e.g., f Item 4-a, f Item 4a, f I4a, fItem 4b, fItem 4c, etc.)
C. For secondary evidence that has insufficient surface area for this information or that resists visible markings (such as casting material), a subset of this information can be imparted to the secondary evidence if the primary container bears all the information.
D. Identifiers may be placed on the substrate to become a permanent part of the cast, or a paper label may be placed in the back of the cast.

7.1.7.2 Generating a Secondary Evidence Log

Secondary evidence will be itemized and recorded on the FTD Secondary Evidence Log (SEL). At a minimum, the SEL will include the following required fields:

- Laboratory Number
- When applicable, Item Number generated in LIMS for secondary evidence
- Item identifier associated with the primary evidentiary item, preceded by an 'f '
- Quantity of secondary evidence type derived from the primary evidentiary item
- Description of secondary evidence (e.g., cast, bullet, toolmarks)
- Indication if secondary evidence contains hazardous materials
- Page Count
- Name of preparer

7.2 Classification

A. Classification of evidentiary items bearing toolmarks takes place in a Level 1 Analysis to determine if an item bears similar or different class characteristics.
    1. The classification at the Level 1 Analysis will include evaluating for subclass characteristics.
        i. Attempt to determine the impact of any possible subclass characteristics on the comparison examination.
    2. Class differences (discernible or measurable) may result from intentional design decisions made by the manufacturer or from minor variations in tool dimensions or finishing methods that are within acceptable manufacturing tolerances for a particular tool.

B. Class Characteristic measurements will be collected utilizing the requirements in sections 7.2.1 through 7.2.5, as applicable.

7.2.1 Calibration

A. NIST traceable steel rulers, gauge blocks, and weights are recertified every 5 years by an ISO/IEC 17025 accredited vendor whose scope of accreditation covers the certifications performed.
    1. Measurement equipment utilized to report an uncertainty measurement is recertified annually by an ISO/IEC 17025 accredited or evaluated vendor.
B. The listed tools are handled according to manufacturer's specifications. Recertification of the calibration status of the tools will be performed at a minimum every 5 years (unless specified by the vendor) by an ISO/IEC 17025 accredited or evaluated vendor.
        - Alicona® IF Verification tool
        - Alicona® IF Calibration tool
        - Cadre TopMatch/ GelSight® calibration tool
    1. If the tool is damaged or visibly changed, a performance check will be run. Should the instrument fail the performance check, factory qualified maintenance personnel will be called in to assess and repair the instrument and/or make any adjustments needed. If the tool is found to be defective, manufacturer's guidance will be followed.
    2. If a tool fails to obtain the required measurements based on the calibration requirements, it will be recalibrated or pulled from use.
    3. The GelSight® system used at the Terrorist Explosive Device Analytical Center (TEDAC) utilizes a standard ball-grid array to perform a calibration check on the instrument prior to use. If the array is damaged or visibly changed, it will be replaced.

7.2.2 Performance Checks

A. Prior to using listed equipment, performance checks must be completed in order to ensure the accuracy and reliability of measurement results that have an impact on the quality of an examination.
    1. Records of performance checks will be included in the examination records as outlined in section 9.1.12.B of LAB-100.
B. Any instrument that fails to pass the performance check will be taken out of service and marked as such. See section 4.1 above.
C. Stage micrometers will be performance checked on the day of usage, prior to conducting a measurement.
D. Balances, micrometers, and calipers must be performance checked on a semi-annual basis.
E. Performance check procedures for the FTU GelSight/Cadre TopMatch® are located at the instrument.
    1. Performance checks on FTU 3D instruments are carried out based on the manufacturer's specifications. The location of the records are described in Section 8.

2. Performance checks of the calibration on an FTU 3D instrument (referred to as calibration check in the remaining document) will be performed as outlined in the *TopMatch User Manual*.
3. The calibration check interval for a 3D instrument is based on the manufacturer's specifications as outlined in the *TopMatch User Manual*.
4. Performance checks of the status of a 3D instrument in FTU will be performed using a suitable NIST SRM.

F. A calibration check of the status of the GelSight 3D instrument in SBAU-TG will be performed using the GelSight Ball Grid Array. The location of the records are described in Section 8.
G. Performance checks of the status of the Alicona instrument at FTU and SBAU-TG will be performed with a NIST traceable reference standard. The location of the records are described in Section 8.
H. Arsenal weights will be performance checked annually.
    1. Inspect each weight and hanger for damage. Weigh each arsenal weight three times, calculate the average weight and record the average as described in Section 8.
    2. If an arsenal weight has a difference greater than +/- 0.10 lb. from its designated measured weight, it will be removed from service and labeled as such.

7.2.3 Methods for Measuring General Rifling Characteristics (GRCs) of bullets

A. Air gap method: The fired bullet is mounted on one stage of the comparison microscope. A micrometer/caliper is mounted on the other stage. Both stages must be at the same magnification level and in focus. Measure the land or groove impression using the micrometer/caliper and record the measurement to the nearest hundredth or thousandth of an inch.
B. Stereo microscope-micrometer/caliper method: The fired bullet is either held or mounted on a steady surface beneath the stereo microscope. Measure the land or groove impression using the micrometer/caliper and record the measurement to the nearest hundredth or thousandth of an inch.
C. Stereo microscope–grid method: The fired bullet is either held or mounted on a steady surface beneath the stereo microscope. Measure the land or groove impression using the ocular alignment grid and record the measurement to the nearest hundredth or thousandth of an inch.
D. Comparison microscope with built-in micrometer: The fired bullet is mounted on the stage with a built-in micrometer. Align the horizontal edge of the crosshair at one of the anchor points for a land or groove impression, move the horizontal edge of the crosshair to the corresponding anchor point. Measure the land or groove impression and record the measurement to the nearest hundredth or thousandth of an inch.
E. 3D Toolmark Topographical Instrument: See the FTD-211 for guidance on the use of the Alicona® instrument for obtaining scans and performing measurements.

7.2.4 Methods for Measuring Toolmarks (items or casts of toolmarks)

A. Visual method: For items that are too large or bulky and are not conducive to being placed under a microscope, align the edges of a scale/micrometer/caliper with opposing edges of the toolmark and record the measurement using appropriate units.
B. Stereo microscope-micrometer/caliper method: Hold the toolmark or cast, or mount on a steady surface beneath the stereo microscope. Using a micrometer/caliper, measure the appropriate dimensions of the toolmark and record the measurement(s) using appropriate units.
C. Comparison microscope with built-in micrometer: Mount the toolmark or cast on the stage with the built-in micrometer. Align the horizontal edge of the crosshair at one edge of the toolmark, move the horizontal edge of the crosshair to the opposite edge of the toolmark, and record the measurement using appropriate units.
D. Instructions for using the Alicona® Infinite Focus or G5 are located at the instrument.
E. Instructions for using the GelSight/Cadre TopMatch® are located at the instrument.

7.2.5 Method for Measuring Trigger Pull of Firearms

Instructions for measuring the trigger pull of firearms are found in the FTD-211.

7.3 Physical and Visual Examinations

7.3.1 Evaluation and Classification of Physical Evidence

A. Physical evidence is defined for these procedures as an item submitted for comparison based upon its class characteristics. Physical evidence can include various evidentiary items (e.g., photographs, tools, toolmarks, metal components, cartridges, bullet components, electronic files saved to disc).
B. Determine any class and/or physical characteristics of the physical evidence:
    - Weight
    - Dimensions (e.g. Length, Width, and Height)
    - Manufacturer information
    - Type of action
    - Design features
    - Material description
    - Color, texture, mold marks, obvious alterations, etc

7.3.2 Examination of Electronic Evidence

A. Electronic evidence (e.g., photographs and electronic files saved to disc) is defined for these procedures as an item and/or request submitted for examination.
B. Ensure the electronic evidence, when printed or copied, is labeled with the appropriate item identifiers.
C. Determine any class characteristics or observed features outlined in section 7.3.1.B, as applicable.

7.3.3 Comparative Relationships between Physical and Class Characteristics

A. Compare the class and/or physical characteristics between two items to determine their comparative relationships. The comparative relationships will reflect one of these possible outcomes:
    1. The physical dimensions and/or design features of the evidentiary item are eliminated from an item, reference sample, or test item.
    2. The physical dimensions and/or design features present for comparison are insufficient to form an opinion as to whether the evidentiary item is physically consistent with an item, reference sample, or test item.
    3. The physical dimensions and/or design features of the evidentiary item is physically consistent with an item, reference sample, or test item.

8 RECORDS

A. Records of calibrations that are to be maintained in Forensic Advantage (FA) Resource Manager are specified in section 9 of LAB-100.
B. For both FTU and SBAU-TG, calibration certificates are maintained by the applicable unit and via digital upload onto the Forensic Analysis Support Unit (FASU) SharePoint site.
C. Performance check records are maintained in examination documentation.
    1. Performance check records for the Alicona® Infinite Focus microscope and GelSight/Cadre TopMatch® instruments are maintained at the instruments.
        i. Performance and/or calibration check records for a 3D instrument will be maintained and stored within the system and/or externally by the applicable unit.
    2. Performance check records for FTU arsenal weights are maintained in the arsenal weight performance check record in the Balances and Trigger Pull Binder in the FTU. The removal of an arsenal weight from service will also be recorded on the performance check record.
    3. Performance check records for SBAU-TG calipers and micrometers are maintained in the SBAU-TG Performance Check Records Binder in the SBAU-TG.
D. Maintenance records are maintained in FA Resource Manager.

9 CALCULATIONS

When physical evidence is presented with a different dimensional scale than the reference item (object vs. photo), the comparison ratio calculation is suitable for comparison purposes.

$$\text{Comparison ratio: } \frac{\text{A (short measurement)}}{\text{B (long measurement)}}$$

10 LIMITATIONS

10.1 Documentation and Preparation

The composition of the substrate being cast may not be suitable for obtaining microscopic features for comparison purposes. (Porous material (e.g., bone))

10.2 Physical and Visual Examination

A physical and visual examination is not for the purpose of source identification. A comparative relationship conclusion of "physically consistent with" indicates a relationship regarding the evidence. Examinations of electronic evidence may be impacted by data quality and size of the item(s) in question.

11 SAFETY

Based upon the type of item(s) being submitted, appropriate safety measures should be employed during the examination. When handling physical evidence, the Examiner(s) or appropriately trained personnel should be mindful of the potential for biological hazards and take the necessary precautions. Standard precautions should be taken for the handling all evidentiary items, reference materials, and reference standards. Personal protective equipment should also be utilized.

FTD personnel will adhere to the guidelines outlined in the FTD-QRG-Safe Handling of Firearms and Ammunition.

12 REFERENCES

Alicona Manual, latest version

GelSight GSCapture Users' Guide for the GelSight Benchtop Scanner, Jan 2018, SBAU Controlled Document #SAU-1

TopMatch Manual, latest version, Cadre Forensics

SWGGUN, SWGGUN Admissibility Resource Kit (ARK), Scientific Working Group for Firearms and Toolmarks. https://afte.org/resources/swggun-ark. Web 2023.

13 REVISION HISTORY

Revision	Issued	Changes
00	03/03/2023	Drafted with new template requirements. Merged documents FTD-201-07, FTD-232-01, FTD-233-01, and duplicative sections from other FTD Technical Procedures. Updates were made to better define and incorporate the formalized methodology. Adjusted requirement 7.2.2.C to require a performance check on day of usage for all stage micrometer measurements.