San Diego Police Department
Crime Laboratory

Firearms Unit Manual

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1.0 INTRODUCTION

1.1 Unit Functions

Analysts in the Firearm and Toolmark Unit perform a variety of examinations depending on the evidence submitted and the case specific investigative questions asked. These examinations generally include Operability/Functionality, Firearm Identification, Serial Number Restoration, Shooting Scene Reconstruction, and Toolmark Identification. This manual describes the methods, procedures, techniques, and formulas that are routinely used for the examination of physical evidence submitted. For the purposes of this manual, "analyst/examiner" are used interchangeably when referring to laboratory technicians and criminalists; however, only trained individuals who have been competency tested may perform the procedures described within this manual. Furthermore, reports authored by laboratory technicians shall utilize a "RESULTS/CONCLUSIONS" heading in lieu of the "OPINIONS/INTERPRETATIONS" heading more often associated with reports authored by Criminalists. Criminalists may use either heading depending on which is deemed more appropriate for the work performed.

All laboratory requests will be approved, tracked, and assigned by the unit supervisor, unless otherwise specified. When assigned a laboratory request, analysts are expected to evaluate the details of each case (when available), the evidence submitted, and any specific questions submitted by investigators. Analysts then have the discretion to choose which approved methods will be used to provide probative information to the customer in a timely manner.

The procedures described below cannot be expected to address each and every situation or type of evidence encountered; as a result, these procedures are designed to accommodate the majority of evidence received. The procedures, techniques, and/or formulas that are found in this manual are approved for use in the Firearm and Toolmark Unit. Procedures, techniques, and/or formulas not outlined in this manual may need to be validated/verified prior to use. Analysts are highly encouraged to refer to the SDPD Quality Assurance Manual, the unit's reference library, and any available AFTE, OSAC, and/or ASB published resources for additional guidance as necessary.

1.2 Chain of Custody

Refer to the SDPD Quality Assurance Manual for guidance pertaining to chain of custody documentation for routine examinations. Below is a summary of the various workflows associated with the Firearm and Toolmark Unit specifically:

UNLOAD REQUEST (no report or note packet required unless specifically requested):
Watch Commander *(analyst retrieves firearm and signs log)* → Property Room *(property personnel initiate chain of custody to analyst in EvidenceOnQ)* → P2 Shooting Room *(analyst renders firearm safe if possible)* → Property Room *(final disposition of evidence).*

OIS FIREARM REQUEST (no prior approval of supervisor required):
Crime Scene Unit (CSU) Gun Locker *(analyst retrieves firearm; document transfer with internal COC form)* → Firearms Unit *(analyst completes applicable examinations)* → CSU

Gun Locker *(final disposition of evidence; document transfer with internal COC form).*

CONSULTATION REQUEST (no report or note packet required):
Investigator, or primary analyst, retains custody of evidence throughout the examination. If the individual requesting a consultation summarizes the results on behalf of the analyst consulted, then it is best practice to have the consulting analyst review, initial, and date the summary to indicate it is true and accurate.

VERIFICATION REQUEST:
Primary analyst retains custody of evidence throughout the secondary analyst's verification.

OR

Primary analyst → 2nd Opinion cabinet → Secondary analyst → 2nd Opinion cabinet → Primary analyst *(both analysts document transfers to and from the cabinet in case notes, respectively).*

1.3 Evidence Security

Evidence in the Firearm and Toolmark Unit is considered to be in a secure area.

1.4 Trace and Biological Evidence Preservation

If investigators request DNA, CSU, and/or Trace examinations on firearm/toolmark evidence, ideally, that work will be completed by the respective units prior to the Firearm Analysis request being assigned. If, during the initial examination, apparent blood or trace evidence is observed, it should be documented in place with photography and its probative value evaluated based on the case details and investigative questions associated with the evidence.

- If apparent trace evidence is observed and deemed probative, consult with the Trace Evidence Unit for guidance on how to best collect and preserve the evidence.

- If apparent blood is observed and deemed probative, consult with the Firearms Unit Supervisor for guidance on whether a detective has requested to have a sample collected. If directed to collect a sample, the analyst shall swab the appropriate areas. For further guidance on how to swab apparent biological samples, consult with the Forensic Biology Unit.

1.5 Firearm Reference Collection

The unit maintains an extensive collection of firearms which shall be inventoried annually by the unit staff. Addition to and permanent removal from the collection will follow the procedures put in place by the Property and Evidence Unit and Operational Support and will be further tracked via a database spreadsheet, maintained within the unit. If a firearm is temporarily removed by individuals outside of the unit staff, the transaction shall be recorded on the "Check Out Log" located near the entrance of the collection. Firearms associated with the reference collection may be used for the following purposes:

- To assist in identifying the manufacturer, model, and type of recovered firearms and firearm components.
- To provide exemplars for various testing purposes which would otherwise compromise evidence firearms.
- To provide an exemplar resource for training and new method development.
- To provide a source of firearms parts needed to repair evidence firearms that require test firing.
- To provide a resource for the location and style of serial numbers.

1.6 Ammunition Reference Collection

The unit maintains an extensive collection of ammunition which does not require an annual inventory by the unit staff. Additions to the collection will follow the procedures put in place by the Property and Evidence Unit and will be further tracked via a database spreadsheet, maintained within the unit. The ammunition associated with the reference collection may be used for the following purposes:

- To assist in identifying manufacturer, style, and caliber of recovered ammunition components.
- To provide exemplars for various testing purposes which would otherwise compromise evidence ammunition.
- To provide exemplars for training and new method development.

2.0 SAFETY

Many procedures, described within this manual, involve hazardous materials, operations, and equipment. This manual may not address all of the safety concerns associated with each individual procedure. It is the responsibility of the user of this manual to establish appropriate health and safety practices pertaining to each procedure, prior to use or adoption. **In the laboratory environment, firearm and toolmark related evidence is not dangerous if handled correctly and treated with respect.**

No loaded firearms are allowed inside the unit unless they are LE firearms. Occasionally, loaded firearms are received as evidence and require special handling; in these instances, extra caution shall be exercised until the firearm has been rendered safe in the P2 shooting room.

The following universal safety rules shall be observed when handling firearms:

- **All firearms must be treated as though they are loaded until they have been verified otherwise.** This rule cannot be overstressed and must always be followed, whether it is in the crime scene unit, the property room, the firearms unit, the test firing area, or in court.
- Firearms must always have muzzle pointed in a safe direction.
- Analysts must keep their finger off the trigger until ready for firing to commence.
- Firearms must remain unloaded until the analyst and any bystanders are ready for firing to commence.

The following safety rules shall be observed when test firing:

- Prior to acquiring test fires, the primary analyst must ensure that the firearm is safe to handle and operate. If a firearm is unsafe to test fire, from a traditional shooting position, and known samples are required for further analysis, then the analyst should consider test firing utilizing the remote firing cart.
- A second person must be present.
- All individuals present must keep a vigilant awareness of the target and the surrounding environment.
- All individuals present must wear appropriate eye protection.
- All individuals present must wear appropriate hearing protection.
    - *NOTE: It is advised that all individuals use double coverage protection unless testing conditions preclude it (e.g., when performing a qualitative sound suppressor examination).*

- Certain types of firearms and shooting activities may require additional safety procedures. Ultimately, the primary analyst is responsible for exercising good judgment and determining whether it is safe to proceed with an examination, demonstration, difficult unload, etc.

The following safety rules should be observed when handling evidence and/or performing chemical analyses:

- Personal Protective Equipment (PPE) and any additional protective equipment (e.g., HEPA Filter) must be considered in order to avoid exposure to dangerous chemicals and/or bloodborne pathogens.

- All chemicals related to serial number and GSR examinations should be handled in the fume hood or a well-ventilated area.

- It is advised that eye protection be worn when disassembling firearms.

- It is advised that ear protection be worn when performing a primer fire.

3.0 OPERABILTY/FUNCTIONALITY

Within the Firearms Unit of the San Diego Police Department's Crime Laboratory, "operable" is defined as a firearm capable of detonating the primer in an appropriately designed cartridge, cartridge case, and/or shotshell. Within the Firearms Unit of the San Diego Police Department's Crime Laboratory, "functional" is defined as a firearm and/or firearm component (e.g. magazine, manual safety, etc.) capable of performing all applicable steps within the cycle of operations, per its design. All analysts may be called upon to determine the operability and/or functionality of a firearm and/or firearm component; however, only Criminalists with advanced training may diagnose factors contributing to a firearm's inoperable status or the failure of a firearm and/or firearm component to function, per its design.

3.1 Minimum Documentation

All firearms shall have overall images captured of the right profile, the left profile, and the official serial number. The following information shall be documented in the case notes unless unable to discern (the reason for which must be documented):

- Presence of probative trace/biological material (report if collected)
- Caliber/Gauge
- Make/Manufacturer
- Model
- Serial Number
- Type (i.e., pistol, revolver, rifle, shotgun)
- Operating system per design (e.g., lever, bolt, gas, recoil, etc.)
- Visible safeties
- Overall/barrel length measurements (*required for long guns only*)
- General Rifling Characteristics (number, direction, style)
- Operating Condition as received

Analysts may record the following details specific to the firearm at their discretion, unless specifically requested to perform a particular test *(reporting the results of such tests shall adhere to any reporting guidelines listed in the applicable sections):*

- Action type per design (e.g., single, double, etc.)
- Additional internal safeties
- Overall condition
- Trigger pull measurements
- Overall/barrel length measurements (*associated with handguns*)
- Serial Number location
- Supplemental numbers and corresponding locations
- Magazine/cylinder capacity (designated or verified)
- Direction of cylinder rotation
- Presence and location of cylinder flares
- Accessories
- Any other probative details

3.1.1 <u>California Assault Weapons</u>

If an analyst determines a firearm meets the definition of a California Assault Weapon and plans to report such a conclusion, the following additional information shall be documented in the case notes:

- Qualifying Category
- Qualifying Characteristics
- Qualifying Features
- Semiautomatic Functionality as received (per 11 CCR 5471 (hh))
- Barrel/Overall Length (for long guns only)
- Penal Code Reference(s)

3.1.2 <u>Officer Involved Shootings</u>

In addition to the above minimum documentation, when processing a firearm belonging to a law enforcement agent, the following information shall be documented in the case notes and summarized in the laboratory report:

- Condition as received
    - Is the hammer/striker cocked/set or at rest?
    - Is the action closed/locked or open/unlocked?
    - Is the firearm loaded?
        - Is there a cartridge in the chamber?
        - Is there a seated magazine?
    - Are there any accessories or adaptations (post factory)?
        - If present, document type, make, model, and serial number of each accessory/adaptation (unless unable to discern)
        - If present, include statement in notes that function testing was limited to the firearm/magazine only.
- Receipt of unseated magazines
- Full inventory of chamber and magazine(s) contents
    - Written and photo documentation required
- Manufacturer's designated magazine(s) cartridge capacity
    - If unmarked, analysts should consult published literature for manufacturer specifications (if unable to obtain specifications, analysts may check capacity with laboratory ammunition; it shall be documented in the report and case notes if capacity is based on this check).
- Total maximum cartridge capacity of firearm and magazine(s) received based on manufacturer's specifications
- Functionality as received

The following shall be performed on all firearms belonging to a law enforcement agent:

- Barrel/Overall Length Measurements (*required for long guns only*)
    - Measure in as received condition
    - Measure per protocol *(refer to section 3.4)*
- Trigger Pull Examination
- Bore Cast

    - If a muzzle attachment is fixed and impeding access, published literature and/or confirmation from the manufacturer, regarding the rifling technique utilized, may be substituted for a bore cast.
- Test Fire
    - As of August 2025, the SDPD Homicide Unit has granted permission to utilize ammunition (if available) from received magazine(s) provided the follow requirements are met:
        - Perform full inventory of chamber and magazine(s) with appropriate documentation.
        - Document which cartridges were chosen to test fire
        - Retain all test fired bullets and cartridge cases from the LEO firearm.
        - Include statement of forensic benefit in the notes and report
    - *Note: If there is insufficient ammunition received in the magazine, then standard issued ammunition, associated with the parent agency, should be made available for the purposes of generating known standards. If the brand, composition, or style of ammunition provided by the agency appears to differ from that which was received, this shall be documented in the case notes.*

The following may be performed and reported on a case-by-case basis, as requested by investigators:

- Manual Safeties Check
- General Ejection Pattern

3.2 Pre-firing Safety Examination

Analysts shall perform all appropriate safety/function checks on a firearm prior to test firing. The case notes shall reflect, at a minimum, that all applicable pre-firing safety and function checks were performed. Any observations considered out of the ordinary, when performing these checks, and any actions taken to rectify an abnormality prior to test firing, shall also be documented in the case notes. If an abnormality that affects the safety, operability, and/or functionality of a firearm cannot be rectified, and test firing is necessary, analysts should consider remote test-firing, primer firing, or consultation with an advanced examiner *(if the primary analyst is a laboratory technician or trainee).*

Individual case scenarios may require more extensive function checks; however, during a routine firearm examination the following are required:

- Check that the chamber/bore are clear of bulges and/or obstructions.
- Check for any signs of cracks or weaknesses in major parts of the firearm such as the frame, slide, or barrel.
- Check for any missing, broken, or misassembled components (readily visible without disassembly).
- Check for any applicable recalls or warnings associated with the make/model of firearm being examined.
    - If a recall or warning exists, determine whether the firearm demonstrates signs of faulty or unsafe operation.
- Check that the engagement surfaces are holding until the trigger is pulled.
    - This can be accomplished with either a hammer push-off test, six-plane shock test, drop test, or a combination of these tests as

considered appropriate.

- Check that the timing and lock up are functioning as expected.
    - Timing is specific to revolvers whereas lock up is typically associated with manual operating systems.
- Check for multi round burst, binary trigger, or fully automatic conversions.
    - This is accomplished by performing a disconnector test and is specific to semiautomatic firearms.
- Check that all applicable steps within the firearm's cycle of operations are functioning as expected.
    - It is recommended that inert cartridges be used, when dry cycling, in order to protect various components within the firearm.
- Check that any manual safeties block the firing mechanism from releasing, when engaged.
    - *NOTE: Even if a manual safety is functioning as expected, it should never take the place of observing the universal safety rules associated with handling firearms.*

During a routine evidence ammunition examination, the following are required prior to test firing:

- Document caliber, headstamp, basic composition, and style.
- Check for signs of reloading.
- Check for damage to the cartridge case's mouth, neck, body, and/or head.
- Check for proper seating of the projectile and primer.
- Check for existing toolmarks on pertinent surfaces of the ammunition.
- Verify that the ammunition is of the correct caliber for the firearm.
- Verify whether the ammunition is needed for other forensic tests (e.g., DNA, LP, FA Proximity Testing).

On the rare occurrence an examination is performed on a muzzleloader, the following are required prior to test firing:

- Check whether the firearm is an "original" or a modern production.
- Check whether the percussion nipples have oversized flash holes.
- Verify the chamber and barrel are sound.
- Verify the firearm has not been preloaded.
    - If received in the loaded condition, the projectile and charge must be removed to ensure it has been properly loaded. It is recommended to use a downloaded charge if test firing is necessary.

3.3 Trigger Pull Examination

Trigger pull is defined as the amount of force which must be applied to the trigger of a firearm to cause sear release. When performed, the trigger pull of a firearm shall be obtained for all available action types, utilizing standard trigger weights.

NOTE: Set "A" is designated for handguns while Set "B" is designated for long guns. The case notes shall indicate which set of weights was used.

3.3.1 Armorer's Trigger Weight Set

Single Action:

- Ensure the firearm is unloaded.
- Cock/set the firing mechanism.
- Hold the firearm with the muzzle vertical.
- Rest the trigger hook on the trigger where the average finger would normally rest.
    - Ensure the hook is not touching any other part of the firearm.
    - Allow the weights to hang parallel to the bore of the firearm.
- Add weight in ¼ pound increments until the sear releases.
    - Larger increments may be added initially to find the appropriate range for the firearm being tested.
- Check a minimum of three times, recocking/resetting the firing mechanism after each attempt.
- Record the results in the case notes.

Double Action:

- Without cocking the firearm, perform the above listed steps.
- Add weights until the trigger is pulled through the double action sequence and the sear releases.
- Record the results in the case notes.

3.3.2 Reporting Guidelines

Upon request, the trigger pull may be reported as "normal", "light", or "heavy". The trigger pull values shall remain in the notes only and will not be included in the report. For single action, "normal" typically ranges between 3-7 pounds; for double action "normal" typically ranges between 7-12 pounds.

These ranges are general guidelines which may not be applicable to all firearms. If it is required to establish the "normal" trigger pull range for a specific firearm, then either a reference collection firearm or published literature may be consulted. The applicable reference shall be documented in the case notes if the established range differs from those provided above.

3.4 Barrel and Overall Length Measurements

Routine firearm dimension measurements for general documentation may be made using a standard measuring device (e.g., ruler or tape measure). Any measurements critical to determining the possession of a "short-barreled rifle" or "short-barreled shotgun" require the use of the Precision Forensic Testing Model MD-36 (S/N: 0926) measuring device which is fitted with the GEI Model 2020A Stainless Steel Ruler (S/N: C36543).

The following steps shall be followed when measuring the barrel length of a firearm:

- Remove all impermanent barrel extensions, poly chokes, flash hiders, etc.
    - Permanent or tool affixed barrel attachments shall remain in place and be included in the measurements.
- Ensure the action is in a closed and locked position relative to the muzzle for all firearms (except revolvers).
- Place a non-marring rod, of appropriate diameter, down the barrel from the

muzzle end until it contacts the closed breech face.

- Position the adjustable collet until it is flush with the muzzle end of the barrel (or any included extension).
- Remove the rod from the firearm.
- Place the rod in the measuring device and record to the nearest 1/32nd of an inch.

The following steps shall be followed when measuring the overall length of a firearm:

- Remove all impermanent barrel extensions, poly chokes, flash hiders, etc.
    - Permanent or tool affixed barrel attachments shall remain in place and be included in the measurements.
- Place the firearm in the measuring device.
    - If the firearm has a collapsible stock, the firearm must be measured with the stock in its shortest configuration.
    - Additional measurements may be taken to encompass the full range of configurations.
- Ensure the bore is parallel to the ruler.
- Position the muzzle end of the firearm, as close to flush as possible, with the "zero" side of the device.
    - If the barrel has been altered, the longest point of the muzzle must be in contact with the "zero" side of the device.
- Position the adjustable sliding plate, as close to flush as possible, with the other end of the firearm.
    - If the stock/frame has an irregular shape, then position the sliding plate so that it contacts the longest point of the stock, frame, etc.
- Record to the nearest 1/32nd of an inch.

NOTE: If a critical measurement of a firearm is not required, a standard measuring device may be used; the instructions listed above shall be followed. For revolver barrels, measure from the breech end (excluding the cylinder but including the threaded portion within the frame) to the muzzle end.

3.4.1 <u>Critical Measurement Range</u>

The following critical measurements *(when reported)* require reporting the measurement uncertainty to include a reference to the coverage probability:

- Altered barrel length of a shotgun measures between 17¾ & 18¼ inches.
- Altered barrel length of a rifle measures between 15¾ & 16¼ inches.
- Altered overall length of a shotgun or rifle measures between 25¾ & 26¼ inches.

Refer to Appendix E for the current established barrel and overall length measurement uncertainty.

3.4.2 <u>Reporting Guidelines</u>

Unless specifically requested by the customer, barrel and overall length measurements are for documentation purposes only and are generally not reported. If reporting is necessary, then the barrel and overall length will be measured and reported to the nearest 1/32nd of an inch. If the measurement falls within the critical range, the measurement uncertainty will be included in the report. An example of appropriate reporting language is as follows:

"The barrel length was found to be 18 inches +/-1/32nd of an inch at a coverage probability of 95%."

3.5 Bore and Chamber Casting

Several types of casting materials exist for forensic science applications. The silicone-based products are similar and procedurally equivalent, as long as the manufacturer's instructions are followed. Casting material is most often used to evaluate a tool's working surface(s) for the presence of subclass characteristics. However, casting the bore and/or chamber may be useful for the following:

- Determining caliber on unmarked or mislabeled firearms
- Determining land and groove widths
- Isolating potential defects or burrs

Prior to casting, the color, contrast, and ease of application should be considered. Once a casting medium has been selected, perform the following steps to cast a barrel's **chamber**:

- Ensure the firearm is unloaded.
- Field strip the firearm to isolate the barrel (or cylinder if casting a revolver chamber).
- Push a cleaning patch or other appropriate damming material into the barrel until it is ½ to ¼ inch from the beginning of the chamber.
- If desired or necessary, lubricate the chamber with gun oil, a silicone spray, or some other similar substance such as WD40 ®.
- Mix the casting material as per the manufacturer instructions and carefully pour or apply the material into the chamber until it is full.
- Once casting material is set, gently pull on the end of the cast or tap a rod against the cast to remove it.
    - If an air pocket forms during application, it is possible to have a portion of the cast trapped in the chamber. Under these circumstances, additional casting material may be applied. Allow additional time for curing, then remove as described above.
- Label and orient the cast with the appropriate markings.

NOTE: The above listed steps may also be used when casting a firearm's bore. However, in bore casting, typically the last three inches from the muzzle end side, are cast; therefore, it is not necessary to field strip the firearm in order to gain unimpeded access.

3.6 Test Firing

Test firing a firearm is performed for a variety of reasons to include determining operability/functionality, generating standards for microscopic comparisons, and generating muzzle to target test patterns for comparison. Recovery methods include the water tank or bullet traps. No ammunition with a muzzle velocity exceeding 3500 ft/s shall be test fired into any of the recovery devices located on P2. Prior to test firing, consider indexing and/or sequencing each shot if necessary.

If performing a microscopic comparison, a minimum of three test specimens shall be recovered in order to assess variability/reproducibility. For all other analyses, the analyst has the discretion to determine the appropriate amount of test specimens recovered. The type of firearm and the overall analysis being performed will usually dictate the recovery method used, and the amount of test specimens required.

3.6.1 Fired Evidence Recovery Systems

The water recovery tank and the Kevlar bullet trap may be used to recover bullets from handguns or rifles. The Savage Range Buddy™ may be used to recover bullets from handguns only. The Retriev-All and the steel bullet trap may be used to test fire firearms, when recovery of the fired projectile(s) is not necessary. The following steps apply to the water recovery tank, the Kevlar bullet trap, the Savage Range Buddy™ and the Retriev-All™, unless otherwise designated:

- Ensure that the water level is appropriate *(water tank only).*
- Ensure that all applicable lids or doors are closed and properly secured.
- Ensure that the exhaust fans or ventilation systems are activated.
- If the potential for automatic or burst fire is a concern, load no more than one cartridge at a time *(water tank only; Kevlar trap, Savage Range Buddy™ and Retriev-All should only ever have one cartridge loaded at a time).*
    - If demonstrating a firearm's ability to perform automatic, burst, or binary function(s) is probative, such test firing shall be performed utilizing the steel bullet trap and no more than three cartridges shall be loaded at a time unless required to recreate a specific case scenario *(the unit supervisor shall be informed of such occurrences in order to determine whether the analysis should proceed).*
- Fire the firearm.
    - If the firearm is capable of firing both single and double action modes, a minimum of one shot per mode shall be performed.
- Recover the applicable ammunition components using an appropriate device.

3.6.2 Remote/Primer Firing

During the course of a firearm examination, it may be determined that it would be unsafe for the analyst to test fire the firearm by holding it as designed. If it is not necessary to obtain test standards for comparison purposes or for entry into the Integrated Ballistics Identification System, then the operability of the firearm may be established utilizing a primed cartridge case or shotshell. Furthermore, if examining a firearm with a manual operating system, the functionality of the firearm may be established in the same way.

If it is necessary to obtain test standards, the firearm should be test fired remotely. Refer to the remote firing device's procedures manual for further instruction.

NOTE: It is recommended that bullet resistant clothing be worn (e.g., a bullet proof vest) if remote firing is to be performed. Furthermore, analysts should consider loading no more than one cartridge during the initial testing.

3.6.3 Observational Ejection Pattern

There may be occasions when only the general approximate direction of ejected cartridge case(s) from a particular firearm is requested (e.g., right and to the rear, forward, etc.). If these observations are all that is requested, the general direction may be included in the report. More detailed testing/mapping of ejection patterns is not currently performed by the Firearms Unit. The following steps are recommended to determine the general ejection pattern:

- Load at least five cartridges.
- Aim the muzzle of the firearm at the center of the steel bullet trap, ensuring that the barrel remains parallel to the floor.
- Without altering the shooter's stance, rapidly discharge all loaded cartridges.
- Secondary personnel in the shooting room shall observe the direction the fired cartridge cases travel, when ejected from the firearm.
- Record the general direction in the case notes.
- Retain or discard the cartridge cases, per analyst's discretion.

3.7 Malfunctioning/Full Auto/Homemade Firearm Examination

Criminalists with advanced training may be called upon to examine a firearm that has been altered, to diagnose the cause of a reported malfunction, or to determine whether a homemade device qualifies as an operable firearm. In instances of alteration or malfunction, it should be the goal of the examiner to acquire a detailed account of the incident prior to thoroughly examining and testing the firearm. Examinations may include external and internal observations, x-ray examinations and striking or dropping the firearm in attempts to either duplicate or refute the incident as reported.

All examinations should be conducted in a manner so as not to alter or damage the firearm. Damage accrued in the laboratory may prevent the examiner from determining the cause of a reported malfunction or duplicating a particular case scenario. If accidental damage to the firearm occurs as a result of analysis, the case notes shall reflect the damage sustained and the unit supervisor shall be consulted for how best to proceed.

MALFUNCTIONING/ALTERED FIREARMS:

No one procedure can sufficiently outline the steps necessary to examine a firearm for all possible malfunctions or alterations. However, the following list of examinations and questions should serve as a guideline; albeit not all categories may be required depending on the case scenario. All abnormal results and/or significant observations made throughout the examination should be summarized in the case notes.

Perform a physical check of the condition of the firearm as received:

- What position is the firing mechanism in?
- What position are the external safeties in?
- Is there a cartridge in the chamber?

- Is there an ammunition source present (i.e., loaded magazine or cylinder)?
- Are there any fired cartridge cases remaining in the chamber or action?
- Should the firearm be x-rayed prior to disassembly?

Note any visual abnormalities/damage:

- Is the barrel loose, cracked, bulged, obstructed, etc.?
- Are there any cracks or weak points associated with the slide/frame/receiver?
- Are there any significant parts broken or missing?
- Are there any screws or pins broken or missing?
- Are there any visible alterations or adaptations?
- Are the sights broken, bent, missing?
- Are there signs of excessive rust/corrosion?

Perform overall function check of the operating system:

- Are there any warnings or recalls associated with the firearm based on literature or case data?
- Is the firearm capable of feeding, loading, locking, firing, unlocking, extracting, ejecting, and resetting the firing mechanism (per its design) when simulated with inert "dummy" cartridges?
    - If any step cannot be performed, consider examining all related internal components *(recommended to test fire or primer fire prior to disassembly).*

Perform external checks:

- Are all parts accounted for and properly assembled?
- Does the slide/cylinder lock into battery?
- Do the external safeties block firing when engaged?
- Are the applicable springs under tension when the hammer/striker are cocked/set?
- Are the internal engagement surfaces holding until the trigger is pulled?
- Are the hammer and striker releasing once the trigger is pulled?
- Does the trigger pull fall within the expected range for all available modes?
- Will the trigger return to its forward position once released?
- Is the disconnector functioning as expected?

Perform internal checks:

- Are all internal parts accounted for and properly assembled?
- Is the firing pin fixed/projecting?
- Are there any signs of burrs, damage, wear, misalignment, or alteration associated with key components? Components to focus on include but are not limited to:
    - Hammer notch(es)
    - Firing pin lug
    - Sear
    - Hand/ratchet *(revolvers)*
    - (Un)Locking components (bolt lugs, cams, locking block, etc.)
    - Trigger

- Extractor/Ejector
- Do the external/internal safeties block firing when engaged?
- Do the internal safeties align with components meant to passively disengage?
- Are there any signs of damage, wear, misalignment, or alteration associated with any springs *(to include the magazine)*?
- Are there any additional signs of adaptation or tampering which would affect the original cycle of operations associated with the firearm being examined?

If potentially unsafe to fire standard ammunition, consider remote firing or primer firing; otherwise, test fire the firearm:

- Is the firearm capable of feeding, loading, locking, firing, unlocking, extracting, ejecting, and resetting the firing mechanism (per its design) when utilizing live ammunition?
- Is the firing pin impression centrally located *(for centerfire firearms)*?
- Is the anvil supporting the rim *(for rimfire firearms)*?
- Are there any unusual toolmarks observed on the fired cartridge cases/bullets?
- Are there any bulged or split cartridge cases?
- Are there any pierced, blown, or high primers on the fired cartridge cases?

<u>HOMEMADE DEVICES:</u>

No one procedure can sufficiently outline the steps necessary to examine a homemade device. However, the following list of questions should serve as a guideline. Results of any test performed, or significant observation made, must be documented in the case notes.

- Does the device have a barrel/chamber compatible with standard ammunition?
    - If an apparent barrel is observed, does it have a rifled bore? Is it unobstructed?
- Does the device have an action capable of (un)locking?
- Does the device have a manual or automatic operating system?
- What is the cycle of operations associated with the device?
- Does the device contain any internal/external safeties?
- Does the device have a trigger mechanism?
- Is the device capable of discharging appropriately designed ammunition?

3.8 <u>Sound Suppressor Examination</u>

A sound suppressor is any device designed to reduce the report of a firearm's discharge by allowing cooling and expansion of the applicable gases. Sound suppressors can be either commercially produced or homemade. When a suspected sound suppressor is received, the primary analyst should preserve and document as much information as possible prior to attempting any live fire examination. The following guidelines should be followed when conducting a sound suppressor examination:

- Determine whether preservation of or chemical testing for gunshot residue is probative.
    - If it is determined to be so, collect swabs from the appropriate

sources prior to any further examination.
    - Refer to Section 5, of this manual, for chemically testing any swabs collected.

- Inspect the device and document the basic construction without disassembling.
    - A borescope or x-ray may be used in order to determine the internal construction.
    - Case notes shall indicate if any characteristics or components are consistent with those expected in commercially manufactured sound suppressors (e.g., internal chambers, baffles, absorbent material, etc.).
    - Case notes shall indicate whether the device has the ability to attach to a barrel.

- If an appropriate firearm can be coupled with the submitted device, then test fire at least one time with the device in place and one time with the device removed *(as long as it has been determined safe to do so).*
    - Document the conditions and environment during test firing.
    - Hold as many variables constant as possible (e.g., ammunition, firing location, firing position, etc.).
    - Document any qualitative observations with respect to a reduction in the firearm's report.
    - If the device is permanently attached to the firearm, then a firearm of the same make, model, caliber, and barrel length may be test fired in order to compare the level of report.

- After test firing has been completed, the analyst may choose to disassemble the device in order to determine any internal construction components.

3.8.1 Reporting Guidelines

There are a variety of ways to report the results of a sound suppressor examination. For commercially manufactured sound suppressors, the following verbiage is recommended:

- By definition, the device qualifies as a "silencer" per CA Penal Code 17210.

For unmarked or homemade devices, it is recommended that the following questions be answered in the "Opinions/Interpretations" section of the report:

- If chemical testing was performed, were there any traces of lead, copper, nitrates, or nitrites?
- Does the device possess design features consistent with a commercially manufactured sound suppressor (namely the presence of internal chambers, an apparent baffling system, and/or any dampening material intended for controlling the expansion, speed, and temperature of gases associated with the discharge of live ammunition)?
- Does the device possess a means for securely attaching to the muzzle end of a

firearm's barrel?
- Based on qualitative auditory observations, was there a reduction in the firearm's report when discharging live ammunition with the device attached?

If all four of the above questions can be answered in the affirmative, then the qualification statement, associated with commercially manufactured sound suppressors, should also be included.

4.0 FIREARMS IDENTIFICATION

Firearms Identification is a discipline of forensic science with the primary concern of determining whether a bullet, cartridge case, or other ammunition component was fired by a particular firearm. The methodology includes pattern matching, through the use of light comparison microscopy and/or virtual comparison microscopy *(latter not currently available at the SDPD laboratory)*, following the ACE-V process utilized by other comparison disciplines. Documentation may take the form of narratives, worksheets, photography, sketches, graphs, or a combination thereof, per analyst's discretion.

4.1 Analysis

Regardless of the ammunition component, when both knowns and unknowns are encountered during the same examination, the ammunition components from an unknown source(s) shall be analyzed prior to those from a known source(s).

At the time of analysis, it is imperative to document the condition of ammunition components collected from a scene or autopsy. The analyst should identify any areas missing, damaged, or distorted as such areas have the potential to alter the appearance of the individual detail and may compromise the analyst's ability to reach a definitive source conclusion.

4.1.1 Internal Shotshell Components

The internal shotshell components most likely to be submitted for examination are shot pellets, slugs, and/or wads, collars, cups, and discs. These items may be used to determine the gauge of the shotgun used, the style of the ammunition, and in some cases the brand of ammunition.

Shot generally refers to multiple spherical pellets used in loading shotshells or cartridges whereas slugs generally refer to a single projectile which may or may not be rifled. Shot can be found in a variety of sizes and compositions (such as lead, bismuth, tungsten, and steel).

Wads, collars, cups, and discs also come in various designs and serve multiple purposes such as reducing the shot pattern, cutting down on deformation during barrel travel, and creating a barrier between the shot and gunpowder.

4.1.1.1 Minimum Documentation

The following information shall be documented in the case notes unless unable to discern (the reason for which must be documented):

- Total number of shot pellets received
  - Note whether pellets all appear similar in size.
- Composition of the shot pellets
  - Composition can be determined through visual examination,

physical examination (compression), microscopic examination, magnetic properties, and chemical analysis.

- Diameter of the best shot pellet specimen (inches)
    - Several pellets may be measured in order to generate an average diameter.
- Weight of the shot pellets (ounces)
    - Different sized pellets must be weighed separately.
- Wad/Slug diameter (inches)
- Wad/Slug composition
- Wad type
- Slug Rifling Characteristics
- Physical condition of the item (image will suffice)

4.1.1.2 Determination of Shot Size

When determining shot size, the analyst should evaluate the number of pellets suitable for qualitative comparison purposes. Intact, relatively spherical shot are of the greatest probative value and should be used whenever available. If several different sizes appear to be present, determine each specific size. Analysts may exercise discretion, based on the evidence received, when choosing which of the following is the most appropriate reference point:

- Diameter
    - Consult known pellet sizes in the AFTE Glossary Appendix or other known literature source and determine shot size based on corresponding diameter.
    - Utilize the Rule of 17 to determine shot size (excluding buckshot).
- Weight
    - Consult known pellet weights in the AFTE Glossary Appendix or other known literature source and determine shot size based on corresponding weight.
    - The weight of the evidence pellets can also be directly compared to the weight of standards using the same number of pellets until a similar known weight is obtained.
- Visual
    - Compare suitable pellets side by side with laboratory standards of known shot sizes until a common size is determined.
        - A stereomicroscope may aid in this determination.
        - This comparison may be done one size at a time or several sizes at a time; however, if more than one size is used at a time, care should be taken not to mix up the shot.
- Record findings in the case notes as well as the source used as a reference.

4.1.1.3 Determination of Gauge Size from Wad, Cup, Disc, Slug

- Directly compare the evidence to known laboratory samples of similar manufacture or composition.

- Measure the base diameter of the wad/slug and compare these to references publishing known measurements.
- Record findings in the case notes as well as the source used as a reference.

4.1.1.4 Reporting Guidelines

The analytical report should convey the following (if able to definitively determine):

- Gauge
- Shot size
- Composition
- Manufacture

Note: If other uniquely identifying features are present on the submitted evidence, and deemed probative to an investigation, it is recommended these also be included in the analytical report.

4.1.2 Bullets

A bullet is a non-spherical projectile used in a rifled barrel. Bullets come in a variety of designs and in many cases may present as jacket fragments or lead cores. The level of probative value is dependent on the amount of information associated with each specimen. The following procedures apply to both damaged and pristine specimens, unless otherwise specified.

4.1.2.1 Minimum Documentation

The following information shall be documented in the case notes unless unable to discern (the reason for which must be documented):

- Presence of probative trace/biological material (report if collected)
- Weight (grains)
- Diameter (inches/millimeters)
- General Rifling Characteristics
    - Style
    - Direction of twist
    - Number of lands and grooves
    - Width of lands and grooves
        - Analysts may exercise discretion on how many impressions are measured. It is best practice to measure multiple lands and multiple grooves in order to adequately represent the rifling and to account for any distortion due to impact damage or worn barrels.
- Physical condition of the bullet, fragment, core, etc. (image will suffice)
- Nominal caliber (if able to determine)

The following information may also be observed and documented per analyst's discretion:

- Composition (core material, jacket material, etc.)

- Nose characteristics (round nose, hollow point, etc.)
- Base characteristics (concave, exposed core, etc.)
- Number, location, and style of cannelures
- Possible manufacturer/marketer of the bullet/projectile
- The presence of gunpowder and/or imprints adhering to the base
- Any extraneous markings to include:
    - Skid/Slippage marks
    - Shave marks
    - Flared base
    - Ricochet marks
    - Post-Firing toolmarks

4.1.2.2 Measuring Land and Groove Widths

A class characteristic associated with fired bullets is the firearm's land/groove widths. If no firearm is submitted, these measurements will be used to generate a list of potential firearms. Therefore, it is imperative that the anchor points, used for beginning and ending a measurement, are consistent and comply with the discipline-wide practice.

Several instruments are available to obtain these measurements; the analyst shall document in the case notes which instrument was utilized.

NOTE: Lead cores are not suitable for obtaining accurate land and groove widths; damaged bullets and jacket fragments may be suitable depending on the level of distortion present.

4.1.2.2.1 Comparison Microscope with Stage Micrometer

- Mount the fired bullet on the left stage of the LEEDS comparison microscope.
- Insert the eyepiece with the crosshair into the microscope's tilting binocular head unit on the right side.
- Adjust the stage until the bullet is clearly visible in the crosshairs.
- Rotate the bullet until both the leading and trailing edges of a land impression are visible and in focus.
- Align the horizontal line of the eyepiece crosshair with the land impression's primary anchor point.
- Zero the stage micrometer.
- Rotate the micrometer dial, in the appropriate direction, to move the horizontal line of the eyepiece crosshair along the y-axis to the land impression's secondary anchor point.
- Record the measurement to the nearest thousandth of an inch or appropriate measurement.
- Repeat this procedure for the remaining land and groove impression(s).

4.1.2.3 Nominal Caliber Determination

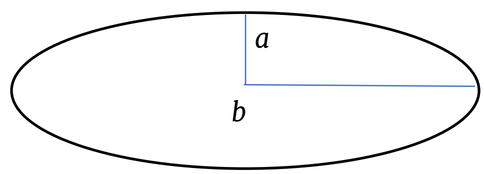
A class characteristic associated with fired bullets is the firearm's nominal caliber, or the approximate diameter of the circle formed by the tops of the lands within a rifled barrel. If no firearm is submitted, caliber may be used to generate a list of potential firearms. It may also be used, in conjunction with the AFTE Glossary, to determine indiscernible general rifling characteristics.

The following techniques may be utilized to determine the caliber of any fired bullets:

- Compare the base diameter of the evidence bullet with a bullet of known caliber.
- Measure the base diameter of the evidence bullet and compare this measurement with known measurements published in reference literature.
- Determine the number and widths of the lands and groove impressions and either mathematically calculate the diameter or refer to the charts in the AFTE Glossary.

The following calculation may be utilized to determine the approximate pre-fired diameter of any bullet with an elliptical base:

$$d = 2\sqrt{\frac{a^2 + b^2}{2}}$$



NOTE: Lead cores are not suitable for determining caliber; however, they may be capable of narrowing down the range of possibilities. Damaged bullets and jacket fragments may be suitable depending on the level of damage and distortion present.

4.1.2.4 Suitability Determination

Typically, fired bullets will have striated toolmarks in the land engraved areas and possibly the groove engraved areas. If observed, the analyst will evaluate the quality and quantity of the toolmarks present and indicate whether the specimen is suitable for microscopic comparison.

Bullets, fragments, and lead cores lacking an appropriate level of individual detail will be labeled as unsuitable for microscopic comparison; the analyst should include any factors contributing to the lack of suitable detail (i.e., damage, distortion, missing surface area, etc.).

4.1.2.5 General Rifling Characteristics Database

The AFTE GRC Database will be utilized when attempting to generate investigative leads. GRC database searches are appropriate when attempting to determine a list of possible firearms that could have fired an evidence bullet when no firearm, or the incorrect firearm, was submitted. If a firearm is submitted and microscopic comparisons are inconclusive, a database search may be performed per the primary analyst's discretion.

4.1.2.5.1 Generating List of Potential Firearms

- Specify which exhibits the search results apply to.
- Enter the caliber and discernible general rifling characteristics of the evidence bullet(s) into the appropriate search field(s).
    - It is recommended to search a range +/-0.003 inches from the average land and groove widths measured. The range may be extended at the analyst's discretion and is used to accommodate any damage and/or distortion by providing a more thorough search.
- Print out the results of the search to include in the case notes.
- Evaluate the results prior to reporting. The list may be narrowed down based on one or more of the following:
    - Bullet design features indicative of a specific caliber (e.g., weight, style, etc.).
    - Limited universe considering class characteristics associated with fired cartridge cases submitted within the same case.
    - Popularity of certain firearm manufacturers within current circulation.

4.1.2.6 Reporting Guidelines

- When reporting caliber, the nominal caliber shall be listed. The report shall not include any specific measurements with respect to diameter, weight, or rifling widths. The following are examples of acceptable reporting structure:
    - 38 nominal
    - 38/9mm
- Specific caliber may be referenced in the "*OPINIONS/INTERPRETATIONS*" section of the report, per analyst's discretion. The following are examples of the suggested verbiage associated with acceptable, qualifying premises:
    - Based on a limited universe, if the bullet(s) is associated with the cartridge case(s), and the class characteristics are considered collectively, then all were most likely fired by a *(specific caliber)* caliber semiautomatic *(type of firearm)* manufactured by one of the following:
    - Based on the weight and/or design features of the projectile, it was most likely associated with a *(specific caliber)* caliber cartridge prior to being fired.
- If caliber cannot be determined due to damage/distortion, the analyst may report that a specimen is consistent with a range of calibers.
- When reporting a list of possible firearms based on a GRC database search, the analyst shall include the following disclaimer: *Note: This list is provided for investigative purposes and may not be considered all inclusive.*

4.1.3 <u>Cartridge Case/Shotshell</u>

A cartridge case is a cylindrical container used to hold all other ammunition components. Cartridge cases are typically metallic and come in a variety of styles. The level of probative value is high due to information stamped directly into the case head and the likelihood of comparable toolmarks from multiple working surfaces associated with a particular firearm.

A shotshell is similar to a cartridge case in that it is a cylindrical container used to hold all other ammunition components. However, shotshells usually combine a plastic hull/tube with a metallic head. The level of probative value is still relatively high due to information included directly on the head and hull/tube as well as the likelihood of comparable toolmarks from multiple working surfaces associated with a particular firearm.

4.1.3.1 <u>Minimum Documentation</u>

The following information shall be documented in the case notes unless unable to discern (the reason for which must be documented):

- Presence of probative trace/biological material (report if collected)
- Caliber or Gauge designation
- Headstamp *(as marked)*
- Firing Pin Shape
- Breech Face Category
- Relative positions of Extractor/Ejector
- Composition

The following information may also be observed and documented:

- Manufacturer/Marketer
- Shotshell body markings *(e.g., length, dram equivalent, shot size)*
- Firing pin aperture shape
- Presence of firing pin aperture shear
- Presence of firing pin drag mark
- Presence of slide scuff marks
- Presence of chamber marks
- Presence of ejection port marks
- Presence of magazine lip marks
- Presence of anvil marks
- Presence of reloading marks
- Presence of apparent machining marks
- Presence of apparent subclass characteristics *(e.g., mold mark or concentric circles in firing pin; gross, continuous, uniformly spaced, linear marks in breech face)*

4.1.3.2 <u>Suitability Determination</u>

Typically, fired cartridge cases and shotshells will have a combination of striated and impressed toolmarks from multiple sources. If observed, the analyst will evaluate the quality and quantity of the toolmarks present and indicate whether the specimen is suitable for microscopic comparison.

On the rare occurrence that a fired cartridge case lacks an appropriate level of individual detail, it will be labeled as unsuitable for microscopic comparison; the analyst must include any factors contributing to the lack of suitable detail (i.e., damage, distortion, extreme rust, etc.). If a laboratory technician is the primary analyst in such cases, a comparison trained analyst shall be consulted prior to declaring any specimen to be "unsuitable".

NOTE: Primer fired cartridge cases and shotshells are unsuitable for IBIS database entry and microscopic comparison due to a lack of individual detail caused by the removal of gunpowder prior to detonation. Once indicated that a primer fire was performed, no additional suitability determination or documentation is required.

4.1.3.3 National Integrated Ballistics Information Network (NIBIN)

NIBIN is a national database used to link firearm related crimes and provide investigative leads. This is accomplished by entering samples into the Integrated Ballistics Identification System (IBIS)and using a proprietary algorithm to search for similarities with previously entered items. IBIS is comprised of an acquisition system (Brasstrax) and a review station (Matchpoint). The acquisition station is used to capture digital images of a select group of toolmarks associated with fired cartridge cases. The review station is used to visually screen the database search results.

Test fired cartridge cases from evidence firearms and evidence cartridge cases collected from a crime scene are both suitable for entry intoIBIS. Firearms that qualify are semiautomatic pistols and rifles in calibers most commonly encountered in crime incidents (*including but not limited to 380 Auto, 9mm Luger, 40 S&W, and 45 Auto*).

The default geographical search area is San Diego County. Investigators must specify, with the unit supervisor, if the search parameters need to be extended to include additional cities, counties, and/or states. Once approved, a manual correlation request will be generated.

The numerical score assigned to each sample entered shall not be used in any way secondary to ranking and shall not be mentioned in reports. If asked about the significance of an IBIS score, the only acceptable response shall be that there is no statistical confidence associated with numeric results from a rank-score only, non-statistically validated scoring function.

4.1.3.3.1 Screening Protocol

Prior to entering applicable specimens into IBIS, a comparison trained analyst will be required to screen all cartridge cases that were received within the same case and were determined to share the same combination of class characteristics *(i.e., caliber, FPI, BFI, and relative EJT/EXT positions).* "Screening" is a general triage used to spot whether multiple firearms are present, based on individual characteristics observed. Due to the abbreviated nature of the screening, no definitive source conclusions will be rendered and therefore no photo documentation or verification is required.

Documentation that the screening was performed will be captured in the primary analyst's case notes and will indicate the following:

- The date of the screening
- Who performed the screening
- The representative sample selected by the comparison analyst for entry into IBIS
    - If more than one specimen is chosen to represent a single group, additional notation by the comparison analyst may be required (e.g., two samples were chosen to accurately represent the variety of ammunition compositions present).

The comparison analyst has the discretion to elevate any case to an advanced microscopic comparison if during the initial screening it was determined that multiple firearms were likely used, and a source conclusion based on individual characteristics would be appropriate to report for investigative purposes. This determination will be made on a case-by-case basis.

- If a case is elevated, the comparison analyst shall proceed as follows:
    - Take possession of the evidence and original notes.
    - Conduct a thorough microscopic comparison as defined below.
    - Enter the representative sample(s) into IBIS and perform all necessary reviews.
    - Draft the final report.

4.1.3.3.2 <u>Brasstrax Entry</u>

Samples may be entered by either the primary analyst assigned to a particular case, or any other analyst who has been trained and competency tested for IBIS Brasstrax acquisitions. Refer to the *IBIS Operations Manual* provided by the system's manufacturer and the Bureau of Alcohol, Tobacco, Firearms, and Explosives, for further instruction on entering samples.

4.1.3.3.3 <u>Matchpoint Review</u>

At a minimum, for every specimen entered, the top 30 correlation results based on the unified score will be reviewed. The case notes shall include the date the results were reviewed and whether or not significant similarities were observed.

When appropriate, refer to the *IBIS Operations Manual* provided by the system's manufacturer and the Bureau of Alcohol, Tobacco, Firearms, and Explosives, for further instruction on linking samples.

4.1.3.3.4 Unconfirmed Lead Notifications

In the event two images are determined to have significant similarities, with respect to the patterns of individual detail digitally captured, the primary analyst may choose to inform investigators of a potential lead prior to comparison of the physical evidence. In order to release the information, the following must occur:

- The primary analyst will capture an image of the best agreement observed via the Matchpoint software.
- The primary analyst will complete the "NIBIN LEAD NOTIFICATION" template found in *Appendix D* of this manual or in the laboratory's shared drive.
- The primary analyst will request a secondary analyst to review the results of the correlation on screen.
    - If the primary analyst is a laboratory technician or a comparison analyst trainee, then the secondary analyst shall be a comparison trained analyst.
    - If the primary analyst is a comparison trained analyst, then the secondary analyst may be any individual who has been trained and competency tested on the Matchpoint software.
- The secondary analyst shall initially review the top 5 correlation results on screen without being informed as to which position the potential match is in.
    - If the secondary analyst detects significant similarities between two images and it corresponds with the same two images that were previously flagged by the primary analyst, then both analysts will initial and date the "NIBIN LEAD NOTIFICATION" template.
        - The two specimens will be marked in Matchpoint as a "Hit".
        - The lead notification will be emailed to all applicable investigators, the unit supervisor, and the NIBIN Administrator *(no technical review is required; however, by initialing the template, the secondary reviewer is also acknowledging having performed a clerical review to detect any administrative errors).*
    - If the secondary analyst does not detect significant similarities between two images during the initial review, then the remainder of the top 30 correlation results should be reviewed.
    - If the top 30 correlation results have been reviewed and the secondary analyst still does not detect significant similarities between two images, then the technical lead shall be consulted to evaluate the two images originally flagged.
        - If the technical lead determines there are significant similarities between the two images, then the primary analyst and technical lead will initial and date the "NIBIN LEAD NOTIFICATION" template and the corresponding steps listed above will be followed.
        - If the technical lead determines there is some similarity, but not enough to warrant releasing the information

prior to confirmation, then the evidence will be microscopically compared in order to reach a definitive source conclusion.
        - If the technical lead is the primary reviewer, then the unit supervisor will assign a third comparison trained analyst to review the results for significant similarities in order to determine whether an unconfirmed lead notification or microscopic comparison of the physical evidence is warranted.
- The primary analyst will complete any additional examinations associated with the request and draft a final report which references the previously distributed unconfirmed lead notification.

4.2 Comparison

Definitive common source conclusions are reached only when sufficient agreement of class, subclass, and individual characteristics is observed between two toolmarks. When it comes to comparing physical items of evidence, light comparison microscopy and virtual comparison microscopy are the two leading tools within the field.

Regardless of the ammunition component, when both knowns and unknowns are encountered during the same examination, the ammunition components from a known source(s) shall be compared to each other prior to comparing a known source(s) specimen versus an unknown source(s) specimen.

4.2.1 Class & Subclass

- Specimens sharing all class characteristics must be microscopically compared at the individual characteristics level in order to reach a definitive source conclusion (i.e., identification/exclusion).

- Specimens with different class characteristics may be excluded from sharing a common source without being microscopically compared at the individual characteristic level.

- For bullets, the potential for subclass is determined by examining a bore cast; therefore, if no firearm is submitted, it is acceptable to compare at the class characteristics level only; however, no definitive source conclusion will be rendered. If an analyst chooses to proceed to microscopic comparison of individual characteristics, any definitive source conclusion must refer to the possibility of subclass influence.

- For cartridge cases/shotshells, when potential subclass is identified on one specimen and absent on another, it may be used to exclude the two from sharing a common source. However, analysts should use caution as some subclass toolmarks are faint and may not reproduce consistently, depending on the ammunition used and the time in between the shooting events.

4.2.2 Individual

- Mount two test fires on the comparison microscope.
    - Search for patterns of individual characteristics unique to that firearm and consider the corresponding working surface in order to determine whether striated toolmarks, impressed toolmarks, or a combination of both are present.
    - Determine the replicability of the pattern from test to test by matching the patterns of the known samples to each other.
    - Choose a specific toolmark or group of toolmarks that stand out; these may be useful as phase points when comparing against unknowns.
- Swap out one of the test fires with an unknown.
    - If no firearm was submitted, two specimens of unknown origin may be compared to each other.
    - If an analyst prefers, or the evidence requires it, specimens of unknown origin may be compared to each other prior to comparison of unknown to known.
- Search for the previous phase point(s) or other replicable pattern(s) within the applicable area on the unknown sample.
- If a similar toolmark or a group of toolmarks is found, maneuver the lines or shapes side by side.
- Continue comparing the particular region of interest.
- Repeat the above steps *(as necessary)* for the next region of interest until all regions of interest have been compared and/or a definitive source conclusion has been reached.
- Repeat the above steps *(as necessary)* for any additional specimens suitable for comparison.

NOTE: When utilizing light comparison microscopy, it is considered best practice to utilize oblique lighting and to begin the comparison at the lowest reasonable magnification.

4.3 Evaluation

- Once a potential pattern match has been found between two specimens, the remainder of that area is evaluated for additional agreement and/or the presence of any disagreement.
    - Per the AFTE Theory of Identification, in order to reach a conclusion of common source, the agreement should be consistent with that seen when two knowns are compared to one another *(i.e., "best known match" or "BKM")* and it should exceed that which has been known to occur between two toolmarks made by different tools *(i.e., "best known non-match" or "BKNM").*

- If the level of agreement is less than the BKM or there are significant areas of disagreement, the analyst must evaluate whether there is a plausible explanation. Plausible explanations may include, but are not limited to:
    - Differences in ammunition style or composition
    - Alteration of the tool's working surfaces

    - Post firing damage and/or distortion
    - Partial substrates (e.g., torn jacket or pierced primer)
    - Lighting
    - Different source

- If areas of disagreement cannot be explained, the analyst may choose to alleviate the effect of controllable variables by performing a combination of the following:
    - Produce additional standards utilizing corresponding ammunition.
    - Change the source and/or angle of light.
    - Change the orientation of the specimens.
    - Clean the specimens.
    - Compare toolmarks associated with a different working surface to determine whether sufficient agreement is present elsewhere.

- Once all applicable areas have been evaluated for level of agreement and/or disagreement, the analyst specifies the final conclusion(s).

4.3.1 Range of Conclusions

The AFTE range of conclusions are generally used when reporting and documenting conclusions for comparison examinations.

4.3.2 Definitions

- **Identification**: Agreement of all discernible class characteristics and sufficient agreement of a combination of individual characteristics where the extent of the 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.

- **Elimination/Exclusion:** Significant disagreement of discernible class characteristics and/or individual characteristics.

- **Inconclusive (A)**: Agreement of all discernible class characteristics and some agreement of individual characteristics, but insufficient for an identification.

- **Inconclusive (B)**: Agreement of all discernible class characteristics without agreement or disagreement of individual characteristics due to an absence, insufficiency, or lack of reproducibility.

- **Inconclusive (C)**: Agreement of all discernible class characteristics and disagreement of individual characteristics, but insufficient for an elimination/exclusion.

- **Unsuitable**: Unsuitable for microscopic comparison due to a lack of class and/or individual characteristics.

4.3.3 Minimum Documentation

The case notes must contain documentation of observations that support a reported conclusion. Methods of acceptable documentation include photography, narrative descriptions, sketches, diagrams, charts, worksheets, tabulation of consecutive matching striae (CMS), or a combination of the above methods.

At a minimum, the case notes shall include written documentation indicating which regions of interest were used to support the comparison decision reached. Photography is strongly recommended to document phase points, key features, and the general level of agreement observed. When images are used, the barcodes being depicted must be included in the case notes.

NOTE: The supporting photographs of one comparison may be used for additional evidence within a case, provided that the agreement depicted is representative of all items that were compared. Such images shall be labeled accordingly (e.g., "firing pin aperture shear's representative level of agreement observed for all specimens compared").

4.4 Verification

All microscopic comparisons resulting in definitive source conclusions shall be verified prior to reporting; this includes identifications and exclusions based on individual characteristics. It is highly recommended that inconclusive results that fall under the "A" and "C" categories be verified; however, this is left to the analyst's discretion.

- Prior to verification, the primary analyst shall finalize all comparison notes to include any conclusions reached.
- All evidence requiring verification may be transferred to the second opinion cabinet, directly to a qualified comparison analyst, or to an approved outside agency.
- The verifying analyst shall conduct an independent microscopic comparison and render one of three conclusions: Identification, Inconclusive, or Exclusion.
    - For efficiency's sake, it is not required or preferable to have the verifying analyst reinventory or reanalyze the evidence received. Written acknowledgement (by the verifier) of the barcodes received, the date of transfer/verification, the method of review, and the final conclusion(s) is sufficient when performing a verification.

4.5 Reporting Guidelines

Results will be reported in line with the standardized AFTE range of conclusions. Inconclusive results must be qualified in the report.

5.0 SHOOTING SCENE RECONSTRUCTION

The majority of shooting scene reconstruction is provided by Criminalists enrolled in the San Diego Police Department's Crime Scene Reconstruction program. However, there are two specific types of analysis that may be performed by the Firearms Unit. These analyses include projectile impact determinations and distance determinations; conclusions are achieved through examination and evaluation of gunshot residues, projectile defects, and/or shot pellet distribution patterns on submitted evidence.

5.1 Visual/Microscopic Examination

- Perform a visual examination of the evidence item utilizing a variety of illumination techniques such as light-emitting diode (LED) or infrared radiation (IR) photography.
- Using either particle picking or an adhesive lift, collect a sample of any burned and/or unburned gunpowder (if present).
    - Document method used for collection
    - Limit collection to outlier particles if possible
- Examine collected particles under a stereomicroscope.

5.1.1 Minimum Documentation

Documentation shall include the following unless unable to discern (the reason for which must be documented):

- General description of the item
- The presence of any probative trace/biological material (report if collected)
    - Include method used for collection
- The presence, location, and general dimensions of any suspected bullet holes
- The presence and location of visible gunshot residues
    - Burned/unburned gunpowder (include shape, size, and color)
    - Metal particulates
    - Vaporous lead (i.e., soot cloud or bullet wipe)
- The presence and approximate dimensions of a visual pattern
    - GSR
    - Shot pellet
- The type of lighting used for examination (include filter type if IR photography performed)

5.2 Chemical Processing

All chemical test formulations can be found in Appendix C. For any chemical tests performed, the reagent log should be checked to ensure it is up to date with the solutions being used. The following sequence of tests for gunshot residues shall be followed:

- Diphenylamine (if suspected gunpowder particles are removed from the object for testing)
- Modified Griess Test

- Dithiooxamide (DTO)
- Sodium Rhodizonate

NOTE: These standardized tests originated as industrial spot tests for various elements and compounds. The origins of these tests are credited to the chemist Fritz Fiegel in his published work entitled "Spot Tests in Inorganic Analysis and Spot Tests in Organic Analysis." There are also a variety of published reference materials which apply these tests to the detection of gunshot residues.

5.2.1 Diphenylamine

Diphenylamine is a presumptive test used to detect the presence of nitrates, which is indicative of gunpowder. This test should be used on any suspected gunpowder particles which were collected during the visual examination of the evidence item. All particles must be microscopically examined prior to performing this chemical test.

- Perform a positive control by placing a known gunpowder particle in a dry spot well.
- Add 2-3 drops of the Diphenylamine solution to the spot well containing the known gunpowder particle as well as a blank spot well (negative control).
- Evaluate the test medium for any chromophoric reaction.
    - A dark blue reaction is indicative of a positive result for nitrates.
    - No reaction is indicative of a negative result for nitrates.
- Repeat the above steps with the unknown particle(s) to determine whether nitrates are present.
- Record the results of the controls and the result of the unknown particle(s) in the case notes.

5.2.2 Modified Griess Test

The Modified Griess Test is a presumptive test that may be used independently or in conjunction with other tests when conducting muzzle-to-target distance determinations. The Modified Griess test uses a chemically specific chromophoric test for nitrites to detect obscure or faint gunpowder patterns. For the purposes of this test, Quantofix pre-treated paper or laboratory generated Griess paper is acceptable.

NOTE: Quantofix is considered a critical reagent and must be purchased from an approved vendor. The substitution of Quantofix paper for laboratory generated paper has been researched, validated, and published in at least two AFTE Journal articles.

NOTE: Any orange or magenta reaction observed on the test paper indicates a positive result for the presence of nitrite residues. Nitrite residues that come from a source other than a firearm typically appear as a haze, whereas reactions from residues that have come from a firearm typically appear as pinpoint reactions. The size and density of the pinpoint pattern form the basis for determining the distance between the muzzle of a firearm and the first intervening object at the time of discharge.

NOTE: The reverse application technique may be used in place of the direct application technique when testing thick or non-porous items that will not allow the steamed acetic acid solution to penetrate.

5.2.2.1 <u>Direct Application Technique</u>

- Select a suitable location for testing; the use of a fume hood is recommended.
    - Lab generated paper should be placed emulsion side up.
    - Quantofix paper does not require a specific orientation.
- Perform a positive/negative control by testing each corner of the test paper using a nitrite test swab.
    - An immediate orange or magenta color change is indicative of a positive result.
    - An acceptable negative result is obtained when the non-nitrite exposed paper does not exhibit a color change.
- Place the evidence item over the test paper with the suspected pattern side down.
- Index seams, buttons, and/or other reference points.
- Soak a piece of nitrite free cheesecloth or filter paper with the 15% acetic acid solution, and place this over the reverse side of the evidence.
- Apply heat and pressure with an iron until the acetic acid solution treated paper is dry.
    - Iron should be applied at a 90-degree angle only. If processing a large area, DO NOT move the iron laterally. Instead, apply directly to one area, remove the heat, and apply directly to an adjacent area until the entire region of interest has been processed.
- Review and record the results of the controls and the results shown on the test paper in the case notes.
    - It is best practice to scan the test paper as photography may be difficult if using reflective photo paper.

5.2.2.2 <u>Reverse Application Technique</u>

- Select a suitable location for testing; the use of a fume hood is recommended.
    - Position the evidence item with the suspected pattern side face up.
- Perform a positive/negative control by testing each corner of the test paper using a nitrite test swab.
    - An immediate orange or magenta color change is indicative of a positive result.
    - An acceptable negative result is obtained when the non-nitrite exposed paper does not exhibit a color change.
- Wipe, dip, or spray the side of the test paper, which will be in contact with the evidence item, with the acetic acid solution.
- Place the test paper over the questioned area and index seams, buttons, or other reference points.
- Place a piece of nitrite free filter paper or cheesecloth over either the test paper or evidence depending on what is being used for a blank.
- Apply heat and pressure with an iron until the acetic acid solution treated paper is dry.
    - Iron should be applied to a 90-degree angle only (see above).
- Review and record the results of the controls and the results shown on the test paper in the case notes.

    - It is best practice to scan the test paper as photography may be difficult if using reflective photo paper.

5.2.3 Dithiooxamide (DTO)

Dithiooxamide (DTO) is a presumptive test that can be used independently or in conjunction with other tests when conducting muzzle-to-target distance determinations. The DTO test uses a chromophoric reaction to indicate the presence of copper; a positive reaction produces a dark, greenish grey to nearly black color change. This test can effectively be used in determining the physical characteristics of bullet holes including directionality of the projectile *(i.e., entrance versus exit).*

NOTE: DTO will also react with cobalt/nickel which result in amber/violet color changes, respectively.

5.2.3.1 Direct Application Technique

- Perform a positive/negative control.
    - Apply 2-3 drops of the ammonium hydroxide solution to a blank sheet of filter paper.
    - Rub the treated area against a known source of copper.
    - Apply 2-3 drops of the DTO solution, covering both the treated and untreated portions of the filter paper.
    - Evaluate the test medium for any chromophoric reaction.
        - A dark green reaction is indicative of a positive result for copper.
        - A lack of green reaction outside of the test mark is an acceptable negative reaction.
- Repeat the above applications of ammonium hydroxide and DTO directly on all areas or holes to be tested on the evidence.
    - Both sides of a hole should be tested if there is a question of entrance versus exit.
- Review and record the results of controls and the results associated with the evidence.

5.2.3.2 Lift Technique

- Perform a positive/negative control following the above listed steps.
- Apply 2-3 drops of the ammonium hydroxide solution on a piece of fresh filter paper.
- Place the treated filter paper over the area to be tested.
- Place a second piece of filter paper over the first and apply moderate pressure for approximately 5 seconds.
- Remove both pieces of filter paper and apply 2-3 drops of the DTO solution to the area that was in direct contact with the evidence item.
- Evaluate the test medium for any reaction.
- Repeat the above process on all areas or holes to be tested.
    - Both sides of a hole should be tested if there is a question of entrance

  versus exit.
- Review and record the results of controls and the results associated with the evidence in the case notes.

5.2.4 <u>Sodium Rhodizonate</u>

Sodium Rhodizonate can be used independently or in conjunction with other tests when conducting muzzle-to-target distance determinations. This test uses a chemically specific chromophoric test for lead which is effective in determining the physical characteristics of bullet holes including determining directionality of the projectile *(i.e., entrance versus exit).*

NOTE: If photo documenting positive results, the photograph should be taken quickly, as the positive reaction may fade overtime.

5.2.4.1 <u>Direct Application Technique</u>

- Perform a positive/negative control.
    - Place a test mark from a known source of lead onto a blank sheet of filter paper.
    - Spray the Sodium Rhodizonate solution onto the test mark as well as the surrounding area.
    - Spray the buffer solution onto the test mark as well as the surrounding area
    - Evaluate the test medium for any reaction.
        - A pink color change is indicative of a presumptive positive result for lead.
    - Spray the tested area, or a portion thereof, with the hydrochloric acid solution.
    - Evaluate the test medium for any reaction.
        - A dark purple color change is a confirmatory positive result for lead.
        - Test results that lack the confirmatory lead result may be reported as a presumptive positive for lead but must clarify that lead was unable to be confirmed.
- Repeat the above sequence of processing steps on all areas or holes to be tested.
    - Both sides of a hole should be tested if there is a question of entrance versus exit.
- Review and record the results of controls and the results associated with the evidence.

5.2.4.2 <u>Bashinsky Transfer Technique</u>

- Perform a positive/negative control by following the sequence of above listed steps.
- To perform the Bashinsky Transfer, uniformly dampen a piece of filter paper with the acetic acid solution.

- Place the treated filter paper over the area to be tested.
    - If additional support is needed, place a second piece of filter paper over the first and apply moderate pressure or a hot iron for approximately five seconds.
- Remove both pieces of filter paper and chemically process the filter paper that was in direct contact with the evidence item.
    - Apply the Sodium Rhodizonate solution.
    - Apply the buffer solution.
    - Evaluate the test medium for any reaction.
        - A pink color change is indicative of a presumptive positive result for lead.
    - Apply the hydrochloric acid solution.
    - Evaluate the test medium for any reaction.
        - A dark purple color change is a confirmatory positive result for lead.
        - Test results that lack the confirmatory lead result may be reported as a presumptive positive for lead but must clarify that lead was unable to be confirmed.
- Repeat the above steps on all areas or holes to be tested.
    - Both sides of a hole should be tested if there is a question of entrance versus exit.
- Review and record the results of controls and the results associated with the evidence.

5.3 Interpretation and Reporting of GSR Results

The observations made during the visual examination and chemical testing may provide probative information regardless of whether or not a test pattern was generated. Analysts should evaluate the results and determine if any of the following interpretations may be made and reported:

- Indications of a firearm discharge:
    - Presence of vaporous lead (smoke)
    - Presence of particulate metals (lead, copper, brass)
    - Presence of nitrites (burned/partially burned gunpowder)
    - Presence of nitrates (unburned gunpowder)
    - Presence of melted and/or adhered gunpowder

- Indications of the passage of a bullet:
    - Presence of a hole in the item
    - Presence of a visible ring around the perimeter of the hole
    - Presence of particulate metals (lead, copper, brass)
    - Relative location of hole or tear to a recovered bullet

- Indications of muzzle to target contact at time of discharge:
    - Presence of ripping or tearing (particularly in a cruciform or stellate pattern)
    - Presence of burning or singeing

- Presence of melted synthetic fibers
- Presence of heavy vaporous lead residues
- Relative location of hole or tear to a recovered bullet

5.4 Distance Determinations

Muzzle-to-target distance determinations will be performed on inanimate objects ONLY. In order to properly perform a muzzle-to-target distance determination, it is usually necessary to generate test patterns at varying distances until a pattern similar to that present on the evidence item is produced. It is essential that the questioned firearm and ammunition, or ammunition consistent with the questioned ammunition be used.

The test media for generating test patterns should be an appropriately sized piece of cardboard, poster board, heavy paper, Benchkote®, cotton twill, material consistent with the evidence, and/or the evidence material itself.

5.4.1 Test Pattern Production

- Make a preliminary determination of the distance intervals to be tested based on the availability of the evidence ammunition.
    - Appropriate distances when generating GSR test patterns typically fall between 0 to ~36 inches.
    - Appropriate distances when generating shot pellet test patterns typically fall between ~5 and ~60 feet.
- Choose an appropriate testing medium (both type and size) and mount to target stand at predetermined distance(s) downrange.
- Load the questioned firearm with appropriate ammunition.
    - Equivalent brand laboratory ammunition may be used initially to establish an appropriate range if there is a limited amount of evidence ammunition.
    - Evidence ammunition should be used (when available) to generate test patterns which will be chemically processed and evaluated to render a final conclusion regarding muzzle-to-target distance.
- Mount the loaded firearm into a remote firing device and ensure the muzzle is level.
- Maneuver the remote firing device into position and verify the distance with a calibrated laser measuring device.
    - Document the laser measuring device that was used in the case notes.
- Fire the firearm.
- Repeat the above sequence of steps with a new testing medium for each additional distance to be tested.
    - If feasible, each test shot should be fired at least two times in order to establish reproducibility.
- Perform a visual examination on each test pattern.
    - The level of documentation shall mirror what was recorded when performing this step on the evidence pattern.
- Perform the applicable chemical tests on each test pattern (if distance is GSR

based).

5.4.2 <u>Pattern Comparison</u>

For muzzle to target distance determinations, a bracket must be established to include a distance which has been determined to be too close and a distance which has been determined to be too far. In order to accomplish this, a side-by-side comparison of the chemically developed questioned pattern(s) and the chemically developed known pattern(s) is performed. The following will be evaluated when establishing this bracket:

- Size of the pattern (developed by the Modified Griess test)
- Density of the pattern (developed by the Modified Griess test)
- Presence or absence of a vaporous lead cloud (developed by the Sodium Rhodizonate test)

5.4.3 <u>Reporting Guidelines</u>

Acceptable reporting example: "The muzzle to target distance was determined to be greater than X but closer than Y."

Unacceptable reporting example: "The muzzle to target distance was determined to be X (in/ft)."

NOTE: If a distance cannot be determined and negative chemical test results are obtained, these negative results shall be reported.

6.0 SERIAL NUMBER RESTORATION

Serial numbers may be obliterated or masked in a variety of ways. The serial number may be restored if the obliteration is not deeper than the compression zone created when a metal surface has been penetrated by a die stamp. Restorations are not limited to serial numbers associated with firearms.

6.1 Visual Examination/Minimum Documentation

When attempting a serial number restoration, the following shall be documented in the technical record:

- General description and overall physical condition of the object containing the obliterated serial number
- Location of obliteration/restoration attempt
- Medium obliteration found in/on (i.e., magnetic/non-magnetic)
- Method of obliteration (if discernible)
- Initial observations to include partial characters
- Surface preparation methods to include any solvents used to clean the surface
- List of chemicals used during restoration
- Significant changes throughout restoration
- Final result

NOTES:

- *For firearms, descriptions must include caliber, manufacturer, model, and general type.*
- *All other analytical tests should be performed on firearms prior to attempting chemical restoration.*
- *Documentation shall include whether all chemicals functioned as expected (i.e., reacted with the substrate via bubbling, color change, etc.).*
- *If documenting observations via sketch, the characters must resemble what is actually observed versus how a character may be routinely written.*
    - *At the completion of chemical processing, any characters that have been definitively determined may be documented in any style.*
- *Partially restored characters may be narrowed down to the most likely per the analyst's discretion.*

6.2 Surface Preparation

It is desirable to remove any grinding and/or filing marks introduced during the original obliteration. Polishing can be effective independently, but it is more often used in conjunction with various chemical etching procedures.

- Use an appropriate cleaner or solvent (such as acetone) to remove any obscuring material.
- Polish the area of the obliteration using either:
    - Dremel type tool with a sanding/polishing disc
    - Fine grit sandpaper
- Continue polishing until the surface is mirror-like, removing all superficial scratches.

    - If the obliteration is severe, it may not be possible or desirable to remove all of the scratches/gouges and polishing should be performed in stages.
- Record any visible characters.
    - If characters do not become visible, proceed to the appropriate chemical etchant.

6.3 Chemical Restoration

Chemical restoration, sometimes referred to as chemical etching, is suitable for restoration of serial numbers stamped in metal. The utilization of chemical etchants will affect the compressed area of the obliterated number faster and to a greater degree than the surrounding non-cold-worked area.

- Apply the appropriate series of chemical solutions to the area of obliteration; beginning with the weakest etchant suitable for the metal type being processed.
    - It is best practice to transfer small amounts of an etchant into a separate container as a "working solution."
    - Cotton swabs shall be used as one-time applicators and then set aside for disposal rather than "double dipping" in the working solution.
    - Any remaining chemical etchants may be disposed of in the laboratory sink after being neutralized with sodium bicarbonate (acceptable pH range: 6-9).
        - The neutralization and disposal will be documented on the "Acid Neutralization Log" located on the unit's fume hood.
    - All used cotton swabs shall be neutralized as described above, placed into a sealed plastic bag, and discarded into an appropriate receptacle.
- Record any characters that develop.
    - Photographs are the recommended documentation method; however, if unable to capture restoration with photography, sketch the developed characters. If the latter is performed, it is best practice to have a second observer confirm the results; however, this is not required. If a secondary observer confirms the results, the individual must date and initial the results in the primary analyst's notes.
    - If no characters develop, try a stronger etchant or one with a different base reagent for a possible change in contrast.
    - The strength of the etchant may continue to be increased, per the analyst's discretion, until all characters have been restored or the material has been etched past the point of restoration.

ETCHANTS FOR MAGNETIC MEDIA (WEAK→STRONG)	**ETCHANTS FOR NON-MAGNETIC MEDIA (WEAK→STRONG)**
Davis Reagent	Ferric Chloride
Turner's Reagent	Acidic Ferric Chloride
Fry's Reagent	25% Hydrochloric Acid
25% Hydrochloric Acid	10% Sodium Hydroxide
Nitric/Phosphoric Acid	Nitric/Phosphoric Acid

NOTE: The formulations for the above listed etchants can be found in Appendix C. Additional etchants may be used at the discretion of the analyst. If an additional etchant is to be used, the analyst must include a reference from a reputable literature source associated with that particular event. Furthermore, if unable to complete the restoration in one sitting, clear polish may be applied to protect and preserve the substrate for future restoration attempts.

6.4 Reporting Guidelines

Any restored serial numbers should be reported in full. The analyst may exercise discretion when reporting partially restored serial numbers. If a partial serial number is reported, it should be clear which characters were not restored. Typically, this is done by including a special symbol (e.g., #, *, @) in place of an unrestored character. The analyst may choose to list the possible choices for any unrestored characters. The following are examples of acceptable reporting formats:

- 123-45678 (restored in full)
- ABC123 US (Glock restored in full w/ suffix)
- P 1234567 (Hi Point restored in full w/ prefix)
- 123-#56#8 (partially restored)
    - "#" denotes unrestored numerical characters
- A@C12# US (partially restored Glock)
    - "@" denotes an unrestored alphabetical character and could be either a B, P, or R
    - "#" denotes an unrestored numerical character and could be either a 3 or an 8

7.0 TOOLMARK IDENTIFICATION

Toolmark Identification is a discipline of forensic science with the primary objective of determining whether a toolmark was made by a particular tool. The methodology includes pattern matching, through the use of light comparison microscopy and/or virtual comparison microscopy *(latter not currently available at the SDPD laboratory)*, following the ACE-V process utilized by other comparison disciplines. In the following sections, the same level of documentation is required for both items from a questioned source and items from a known source. Documentation may take the form of narratives, worksheets, photography, sketches, graphs, or a combination thereof, per analyst's discretion.

NOTE: Due to the time, difficulty, and quantity of variables capable of affecting toolmark generation, comparison, and identification, investigators shall consult with the technical lead and/or the unit supervisor prior to submitting a toolmark identification request. The consultation will generally focus on whether the suspected tool is available and has been linked to a suspect. The availability of the object containing the toolmark will also be evaluated.

7.1 Physical Examination and Classification of Tools

The following information shall be documented in the case notes unless unable to discern (the reason for which must be documented):

- The presence of probative trace/biological material (report if collected)
- Tool type
  - Brand name
  - Size/dimensions (e.g., handle length, blade length, jaw width, etc.)
  - Action
- Tool condition
  - Note any defects, damage, distortion, or otherwise altered areas associated with the tools working surface(s).

7.2 Generating Toolmark Standards

In order to compare a questioned toolmark with a suspected tool, toolmark standards are typically made with the suspected tool. The basic objective in preparing toolmark standards is to attempt to duplicate the manner in which the tool was used during the incident. The following systematic approach should be used for the production of toolmark standards:

- Select an appropriate test substrate.
  - Lead is usually the first material utilized.
    - The initial test medium must be soft enough to prevent alterations of the tool's working surface.
    - Subsequent tests might require the use of media that are harder, or otherwise more similar to the evidence item.
    - If sufficient evidence material is provided, the evidence material may be the best media to generate the final test toolmark standards.
  - Bring the tool in contact with the substrate and apply force and the

appropriate lateral or orthogonal movement to create a striated or impressed toolmark.

- Considering altering pressure, angle, direction, or other appropriate variables when creating the toolmark standards.
- Consider the possibility that the tool was not applied in a standard way, per its design (e.g., a screwdriver used to pry open a door).

- Index the tool and toolmark as appropriate. Consider the following:
    - Directionality
    - Working surface and corresponding toolmark

7.3 Toolmark Analysis

Regardless of workpiece, when both knowns and unknowns are encountered during the same examination, the workpiece(s) with toolmarks from an unknown source(s) shall be analyzed prior to those with toolmarks from a known source(s).

At the time of analysis, it is imperative to document the condition of the workpiece and tool collected from a scene. The analyst should identify any areas missing, damaged, or distorted as such areas have the potential to alter the appearance of the individual detail and compromise the ability of an analyst to reach a definitive source conclusion.

7.3.1 Minimum Documentation

The following information shall be documented in the case notes unless unable to discern (the reason for which must be documented):

- Workpiece medium
- Physical characteristics of toolmark
    - Striated vs. Impressed
    - Length
    - Width
- Directionality of toolmark
- Tool type/action
- Any apparent changes in tool direction or force

7.3.2 Suitability Determination

Depending on the application of a tool, impressed toolmarks, striated toolmarks, or a combination of both may be present. If observed, the analyst will evaluate the quality and quantity of the toolmarks present and indicate whether the specimen is suitable for microscopic comparison.

Toolmarks lacking an appropriate level of individual detail will be labeled as unsuitable; the analyst shall include any factors contributing to the lack of suitable detail (i.e., damage, distortion, missing bearing surface, etc.).

7.3.3 **Toolmark Casting**

Several types of casting materials exist for forensic science applications. The silicone-based products are similar and procedurally equivalent, as long as the manufacturer's instructions are followed. Casting material is most often used to evaluate a tool's working surface(s) for the presence of subclass characteristics. However, casting toolmarks may assist an analyst for a variety of reasons.

For example, casts may be used if an item received for toolmark examination is too large to be conveniently placed on the microscope's stage. Additionally, casts may be appropriate or preferred when an item is too reflective or the toolmark depth makes it difficult to adequately illuminate the workpiece(s). If a toolmark from an unknown source is cast, any toolmark standards created will also have to be cast in order to perform a microscopic comparison.

If casting toolmarks is determined to be the best course of action, the following steps should be followed:

- Select an appropriate casting material.
    - Color, contrast, and ease of application are some points to consider when selecting.
- Prepare the item's surface prior to applying the casting material.
    - Consider the effects of cleaning or other preparation activities performed on the item's surface that can be transferred to the cast.
    - Document preparation activities in the case notes, as appropriate.
- Prepare a backing card (when applicable) of an appropriate material with identifying information and orientation marks.
    - Alternatively, be prepared to place identifying information and orientation marks directly on the cast.
- Prepare the casting material according to the manufacturer's specifications.
- Place the casting material on the desired toolmark.
    - A toothpick or similar fine-tipped object may help reduce bubbles that can form in the casting material due to recessed areas.
    - If possible, place the backing card on the exposed side of the casting material.
- Allow the cast to cure based on the manufacturer's instructions.
- Gently lift the cast off the toolmark and examine for any voids or defects.

7.4 **Toolmark Comparison**

Definitive common source conclusions are reached only when sufficient agreement of class, subclass, and individual characteristics is observed between two toolmarks. When it comes to comparing physical items of evidence, light comparison microscopy and virtual comparison microscopy are the two leading tools within the field.

Regardless of workpiece, when both knowns and unknowns are encountered during the same examination, the workpieces from a known source(s) shall be compared to each other prior to comparing a known source(s) specimen versus an unknown source(s) specimen.

7.4.1 **<u>Class & Subclass</u>**

- Specimens sharing all class characteristics must be microscopically compared at the individual characteristics level in order to reach a definitive source conclusion (i.e., identification/exclusion).

- Specimens with different class characteristics may be excluded from sharing a common source without being microscopically compared at the individual characteristic level.

- When potential subclass is identified on one specimen and absent on another, it may be used to exclude the two from sharing a common source. However, analysts should use caution as some subclass toolmarks are faint and may not reproduce consistently especially if the user does not utilize the tool per its design.

7.4.2 **<u>Individual</u>**

- Mount two test standards on the comparison microscope.
    - Search for patterns of individual characteristics unique to that tool and consider the corresponding working surface in order to determine whether striated toolmarks, impressed toolmarks, or a combination of both are present.
    - Determine the replicability of the pattern from test to test by matching the patterns of the known samples to each other.
    - Choose a specific toolmark or group of toolmarks that stand out; these may be useful as phase points when comparing against unknowns.
- Swap out one of the test standards with an unknown.
- Search for the previous phase point(s) or other replicable pattern(s) within the applicable area on the unknown sample.
- If a similar toolmark or a group of toolmarks is found, maneuver the lines or shapes side by side.
- Continue comparing the particular region of interest.
- Repeat the above steps *(as necessary)* for the next region of interest until all regions of interest have been compared and/or a definitive source conclusion has been reached.
- Repeat the above steps *(as necessary)* for any additional specimens suitable for comparison.

NOTE: When utilizing light comparison microscopy, it is considered best practice to utilize oblique lighting and to begin the comparison at the lowest reasonable magnification.

7.5 **<u>Evaluation</u>**

- Once a potential pattern match has been found between two specimens, the remainder of that area is evaluated for additional agreement and/or the presence of any disagreement.

  - Per the AFTE Theory of Identification, in order to reach a conclusion of common source the agreement should be consistent with that seen when two knowns are compared to one another *(i.e., "best known match" or "BKM")* and it should exceed that which has been known to occur between two toolmarks made by different tools *(i.e., "best known non-match" or "BKNM").*

- If the level of agreement is less than the BKM or there are significant areas of disagreement, the analyst must evaluate whether there is a plausible explanation. Plausible explanations may include, but are not limited to:
  - Differences in workpiece composition
  - Alteration of the tool's working surfaces
  - Damage and/or distortion
  - Partial substrates
  - Pressure applied
  - Angle of incidence
  - Lighting
  - Different source

- If areas of disagreement cannot be explained, analyst may choose to alleviate the effect of controllable variables by performing a combination of the following:
  - Produce additional standards
  - Change the source and or angle of light
  - Change the orientation of the specimens
  - Clean the specimens
  - Compare toolmarks associated with a different working surface to determine whether sufficient agreement is present elsewhere

- Once all applicable areas have been evaluated for level of agreement and/or disagreement, the analyst specifies the final conclusion(s).

7.5.1 Range of Conclusions

The AFTE range of conclusions are generally used when reporting and documenting conclusions for comparison examinations.

7.5.2 Definitions

- **Identification**: Agreement of all discernible class characteristics and sufficient agreement of a combination of individual characteristics where the extent of the 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.

- **Elimination/Exclusion:** Significant disagreement of discernible class characteristics and/or individual characteristics.**Inconclusive (A)**: Agreement of all discernible class characteristics and some agreement of individual characteristics, but insufficient for an identification.

- **<u>Inconclusive (B)</u>**: Agreement of all discernible class characteristics without agreement or disagreement of individual characteristics due to an absence, insufficiency, or lack of reproducibility.

- **<u>Inconclusive (C)</u>**: Agreement of all discernible class characteristics and disagreement of individual characteristics, but insufficient for an elimination/exclusion.

- **<u>Unsuitable</u>**: Unsuitable for microscopic comparison due to a lack of class and/or individual characteristics.

7.5.3 Minimum Documentation

The case notes must contain documentation of observations that support a reported conclusion. Methods of acceptable documentation include photography, narrative descriptions, sketches, diagrams, charts, worksheets, tabulation of consecutive matching striae (CMS), or a combination of the above methods. At a minimum, the case notes shall include written documentation indicating which working surface(s) was used to support the comparison decision reached. Photography is strongly recommended to document phase points, key features, and the general level of agreement observed. When images are used, the magnification and barcodes being depicted must be included in the case notes.

7.6 Verification

All microscopic comparisons resulting in definitive source conclusions shall be verified prior to reporting; this includes identifications and exclusions based on individual characteristics. It is highly recommended that inconclusive results that fall under the "A" and "C" categories be verified; however, this is left to the primary analyst's discretion.

- Prior to verification, the primary analyst shall finalize all comparison notes to include any conclusions reached.
- All evidence requiring verification may be transferred to the second opinion cabinet, directly to a qualified comparison analyst, or to an approved outside agency.
- The verifying analyst shall conduct an independent microscopic comparison and render one of three conclusions: Identification, Inconclusive, or Exclusion.
    - For efficiency's sake, it is not required or preferable to have the verifying analyst reinventory or reanalyze the evidence received. Written acknowledgement (by the verifier) of the barcodes received, the date of transfer/verification, the method of review, and the final conclusion(s) is sufficient when performing a verification.

7.7 Reporting Guidelines

Results will be reported in line with the standardized AFTE range of conclusions. Inconclusive results must be qualified in the report.

APPENDIX A: ABBREVIATIONS

Abbreviation	Definition
ApSh	Aperture Shear
ARC	Ammunition Reference Collection
AW	Assault Weapon
B(s)	Bullet(s)
BF	Breech Face
BFI	Breech Face Impression
Br	Brass
CC(s)	Cartridge Case(s)
CCW	Counterclockwise
Ch	Chamber
CTG(s)	Cartridge(s)
CW	Clockwise
DA	Double Action
DAO	Double Action Only
EJT	Ejector
EjPt	Ejection Port
EXC	Exclusion
EXT	Extractor
FP	Firing Pin
FPDr	Firing Pin Drag
FPI	Firing Pin Impression
FPP	Firearm Processing Packet
FRC	Firearms Reference Collection
GEA(s)	Groove Engraved Area(s)
GI(s)	Groove Impression(s)
gr/gn	Grain
GRC	General Rifling Characteristics
GSR	Gunshot Residue
ID	Identification
INC	Inconclusive
K(s)	Item(s) From Known Source
L	Left
LEA(s)	Land Engraved Area(s)
LI(s)	Land Impression(s)
mag(s)	Magazine(s)
NSSO	No Significant Similarities Observed *(IBIS specific)*
PF(s)	Primer Fired(s)
Q(s)	Item(s) From Unknown Source

R	Right
rec	Received
ref	Reference
ROI	Region of Interest
SA	Single Action
SlSc	Slide Scuff
SSO	Significant Similarities Observed *(IBIS specific)*
TF(s)	Test Fire(s)

APPENDIX B: CALIBRATION/VERIFICATION OF EQUIPMENT

Equipment	External Maintenance/Calibration	Internal Verification	Measurement of Uncertainty Determination Requirement	NIST Traceability Required
Armorer's Hanging Weight Sets	N/A	Annually using the floor scale in the Narcotics Vault[2,4]	NO	NO
Borescope	N/A	N/A	NO	NO
Balances (all)	Annually Serviced[2]	Biannually using Chemistry weights[2,4]	NO	YES
Calipers	N/A	Biannually using gauge blocks[2, 3]	NO	YES
Chronograph	N/A	N/A	NO	NO
IBIS (BRASSTRAX-3D)	Calibrated every 50 acquisitions[1] and 300 acquisitions[1]	N/A	NO	NO
Laser Range Finder	N/A	Prior to use	NO	NO
Comparison Scopes	Annually cleaned and serviced including inspection of the optics[2]	N/A	NO	NO
Stage Micrometers (LEEDS)	Annually serviced[2]	Biannually using MWSM2 Stage Micrometer (SN: 16725, 16726, or 16727)[2,3]	NO	YES
Overall Barrel Length Measuring Device	Calibrated every 4 years[2]	N/A	YES	YES
Stereo Microscopes	Annually serviced[2]	N/A	NO	NO

1 *Performed automatically and remotely by the external system administrator.*
2 *This will be documented in the instrument/equipment records logbook.*
3 *If the verification difference falls outside of the acceptable range, the equipment will be taken out of service until the discrepancy has been remedied through maintenance and/or repair.*
4 *If the verification difference between the measured weight and the expected weight exceeds the manufacturer's tolerance, the equipment will be taken out of service until the discrepancy has been remedied through maintenance and/or repair.*

APPENDIX C: CHEMICALS AND REAGENTS

Chemicals and reagents used will generally be reagent grade or better. None of these chemicals/reagents have a predetermined expiration date and can be used until they no longer perform satisfactorily. None of these chemicals are designated as "critical reagents" and all will be tracked within the unit's reagent log binder. Water, where referenced as part of a reagent, is assumed to be laboratory deionized water, and does not require tracking.

SERIAL NUMBER ETCHANTS:

DAVIS' REAGENT	**TURNER'S REAGENT**	**FRY'S REAGENT**	**SODIUM HYDROXIDE**
5g Cupric Chloride 50mL Hydrochloric Acid 50mL Water	2.5g Cupric Chloride 40mL Hydrochloric Acid 25mL Ethyl Alcohol 30mL Water	90g Cupric Chloride 120mL Hydrochloric Acid 100mL Water	10g Sodium Hydroxide 100mL Water *(10%)*

FERRIC CHLORIDE	**ACIDIC FERRIC CHLORIDE**	**NITRIC ACID**	**NITRIC/PHOSPHORIC ACID**
25g Ferric Chloride 100mL Water	25g Ferric Chloride 25mL Hydrochloric Acid 100mL Water	25mL Nitric Acid 75mL Water *(25%)*	6mL Nitric Acid 94mL Phosphoric Acid

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DIPHENYLAMINE (NITRATE DETECTION):

- Add 0.3g of Diphenylamine to 20mL of concentrated sulfuric acid.
- Pour solution into 10mL of glacial acetic acid.

SENSITIZED GRIESS PAPER (NITRITE DETECTION):

- Add 0.75g of Sulfanilic Acid to 150mL of water and mix thoroughly.
- Add 0.42g of Alpha Naphthol to 150mL of methanol and mix thoroughly.
- Mix the above two solutions in a clean photo tray.
- Saturate pieces of filter paper, inkjet photo paper, or desensitized photo paper in mixed solution.
- Hang to dry then store in an airtight container.

15% ACETIC ACID SOLUTION (USED FOR MODIFIED GRIESS TEST-NITRITE DETECTION):

- Add 15mL of Glacial Acetic Acid to 85mL of water.

NITRITE TEST STRIPS (USED FOR MODIFIED GRIESS TEST CONTROL):

- Dissolve 0.6g of Sodium Nitrite in 100mL of water.
- Saturate cotton swabs in this mixture.
- Allow to dry then store in airtight container.

DITHIOOXAMIDE SOLUTION (COPPER DETECTION):

- Add 0.2g of dithiooxamide to 100mL of water.

25% AMMONIUM HYDROXIDE SOLUTION (USED WITH DTO-COPPER DETECTION):

- Add 25mL of concentrated ammonium hydroxide to 75mL of water.

SODIUM RHODIZONATE SOLUTION (LEAD DETECTION):

- Add 0.05g of Rhodizonic acid to 150mL of water.

TARTARIC BUFFER SOLUTION (USED WITH SODIUM RHODIZONATE-LEAD DETECTION):

- Dissolve 1.9g of Sodium Bitartrate and 1.5g of Tartaric Acid in 100mL of water.
- Apply heat and agitation to expedite dissolve time.

5% HYDROCHLORIC ACID SOLUTION (USED WITH SODIUM RHODIZONATE-LEAD DETECTION):

- Add 5mL of concentrated Hydrochloric Acid to 95mL of water.

APPENDIX D: UNCONFIRMED LEAD NOTIFICATION TEMPLATE

SAN DIEGO POLICE DEPARTMENT
CRIME LABORATORY
FIREARMS UNIT

NIBIN LEAD NOTIFICATION

THIS IS AN UNCONFIRMED RESULT FOR INVESTIGATIVE LEADS ONLY.

REFERENCE CASE:

Agency	Case	Event	Barcode	Evidence Description	Investigating Officer/Detective

LINKED CASE(S):

Agency	Case	Event	Barcode or Exhibit	Evidence Description	Investigating Officer/Detective

OPINIONS / INTERPRETATIONS:

The above information should not be used as the basis for a search warrant, nor should it be presented in court, without prior confirmation by a qualified firearms examiner. If confirmation is required, please contact the unit supervisor, or submit a laboratory request in EvidenceOnQ.

Primary IBIS Reviewer:______________ **Date:**___________________

Secondary IBIS Reviewer:_____________ **Date:**___________________

APPENDIX E: BARREL & OVERALL LENGTH MEASUREMENT UNCERTAINTY

Both Federal and California laws regulate the possession of "short-barreled" rifles and shotguns. California Penal Code 17170 (a/b) generally defines a "short-barreled rifle" as a rifle "having a barrel or barrels of less than 16 inches in length" and/or a rifle with an "overall length of less than 26 inches." California Penal Code 17180 (a/b) generally defines a "short-barreled shotgun" as a firearm having "a barrel or barrels of less than 18 inches in length" and/or a firearm with an "overall length of less than 26 inches." Federal laws have equivalent lengths defined. When requested to opine whether a firearm meets one or more of these definitions, the following critical measurements require reporting the measurement uncertainty to include a reference to the coverage probability:

- Altered barrel length of a shotgun measures between 17¾ & 18¼ inches.
- Altered barrel length of a rifle measures between 15¾ & 16¼ inches.
- Altered overall length of a shotgun or rifle measures between 25¾ & 26¼ inches.

In order to determine our measurement uncertainty for these measurements, we have developed the following plan.

<u>Step 1 –Define the Process</u>

Our uncertainty in the overall length and barrel length of firearms is defined by the following equation:

$Y = x \pm u$ where Y = True Value, x = Measured Value, and u = Calculated Uncertainty

<u>Step 2 –Identify and Quantify the Uncertainty Sources</u>

Procedures

Five firearms of varying lengths and features (stock shape, grip shape, barrel attachments, etc.) will be selected. Over the course of one afternoon, each firearm's overall and barrel lengths will be measured, by each qualified analyst, to the nearest 1/32 of an inch, for a total of five measured firearms per analyst. The measurement process will then be repeated on a different week, over the course of one morning, by the same analysts, using the same firearms.

These measurements will be obtained by following the procedures described in the current Firearms Unit Manual Section 3.4 entitled, "Barrel and Overall Length Measurements".

Equipment

The Precision Forensic Testing, Model MD-36 (S/N: 0926), measuring device fitted with the GEI, Model 2020A (S/N: C36543), stainless steel ruler was sent to Micro Precision Calibration Inc. in Grass Valley, CA to be calibrated utilizing the following NIST traceable standards:

- Starrett, Model SS8A1X (S/N: ME-351582/83), 8-piece Long Gauge Block Set (Traceability#: 551220083843286)
- Mitutoyo, Model 516-901-26 (S/N: AW9727), 81-piece Gauge Block Set (Traceability#: 551220084568145)

- Doall, Model A (S/N: 690-7), Surface Plate (Traceability#: 551220085329989)
- Mahr Federal Inc, Model CX2 DIGIMAR (S/N: 5320102), Height Measuring Machine (Traceability#: 551220084696222)

On December 22, 2022, a calibration report was issued by Micro Precision Calibration Inc. indicating that the GEI ruler was compliant with the specified values of 16, 18, and 26 inches. Based on the calibration report, the variations between the GEI ruler and the NIST traceable standards were determined to be negligible and would therefore not have any significant effect on the uncertainty of measurement calculation. The device is due for recalibration by December 15, 2026.

Staff

Trained employees of the SDPD Firearms Unit will perform the measurements. Human factors such as training, experience, and eyesight will be factored into the study since all examiners will participate equally in the measuring portion of the process for the purpose of calculating the uncertainty of measurement.

Facility

Environmental factors such as varying temperature or humidity may have an effect on the GEI 2020A ruler but are generally negligible as the ruler is located inside a temperature-controlled building. By taking duplicate measurements on different days and at different times, any limited fluctuations are accounted for in the calculation of uncertainty.

Measurand

Measureand refers to the item that is being measured; therefore, in this case the measureand is the firearm. Features of the firearm such as the shape of the stock and the attached accessories may have an effect on the uncertainty of measurement; therefore, five firearms of varying lengths and features (stock shape, grip shape, barrel attachments, etc.) will be selected to account for these variations in the calculation of uncertainty.

Steps 3 and 4 –Quantify Uncertainty and Convert Factors to Standard Uncertainty

Readability

Readability is the scale of our ruler, which is 1/32nd of an inch. Per unit protocol, personnel are instructed to round measurements to the nearest 1/32nd of an inch; therefore, this is a rectangular distribution of values. To calculate the standard deviation of this rectangular distribution, the unit of measurement is divided by 2 (1/32 / 2 = 1/64), which is then divided by the square root of 3 (1/64 / √3 = 0.016).

Repeatability

Each data set obtained *(from our empirical study which repeatedly measured the same firearms using the same method, the same personnel, the same measuring system, and the same location)* was subjected to the Grubbs' test. If a single statistical outlier was detected, it was eliminated from the applicable set. The remaining measurements were then used to calculate the standard deviation. Repeatability was determined from the average of the standard deviations associated with the barrel and overall measurements, respectively (see calculation sheets).

Uncertainty of the Ruler
The certificate of calibration for the GEI 2020A Ruler indicates an uncertainty of 0.0096”. This uncertainty was calculated using a coverage factor of k=2. In order to convert this back to a standard of uncertainty, we divided the uncertainty by 2 (0.0096 / 2 = 0.0048).

Step 5 –Calculate the Combined Standard Uncertainty

We used the Root-Sum-Square method of calculation. Each standard deviation equivalent was squared, and then added together. Then the square-root of this sum was calculated.

$$U_c = \sqrt{(\mathrm{Re}\,adability)^2 + (\mathrm{Re}\,peatability)^2 + (RulerAccuracy)^2}$$

U_c = .049 inches (Overall) U_c = .023 inches (Barrel)

Step 6 –Expand the uncertainty by coverage factor

$U = tU_c$ where U is the expanded uncertainty and *t* is the coverage factor. For these calculations *t* was selected as the coverage factor since the total number of measurements for overall and barrel lengths was below 100, each.

t = 3.355 ± 0.163 inches (Overall) Approximately 95% Confidence Interval
t = 3.355 ± 0.076 inches (Barrel) Approximately 95% Confidence Interval.

Step 7 –Evaluate the Expanded Uncertainty

Our calculated uncertainty, with a Confidence Interval of approximately 95%, was 0.163” (~5/32 of an inch) for overall length and 0.076” (~2/32 of an inch) for barrel length.

The uncertainty will be recalculated in the event of changes in equipment (such as a new ruler or measuring device) or changes in personnel.

Step 8 –Report the Uncertainty

Unless specifically requested by the customer, barrel and overall length measurements are for documentation purposes only and are generally not reported. If reporting is necessary, then the barrel and overall length will be measured and reported to the nearest 1/32nd of an inch. If the measurement(s) obtained on the GEI 2020A ruler falls within the critical range, the measurement uncertainty will be included in the report, to include a reference to the coverage probability.