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1.0 MATRIX PANELS

- Laboratory matrix panels serve several purposes, which include:
  - To document the work done
  - To act as a useful aid in guiding the examination
  - To serve as an archive for future reference

- Matrix Panels are located electronically in LIMS. The examiner's employee number is electronically added to the bottom of all pages. Access to LIMS entry panels is limited to the examiner assigned to the case; this access is password protected via the LIMS log on. Handwritten initials on each page are therefore not necessary.

1.1 Firearm Matrix Panel

- A firearm matrix panel may take on many forms and may include the following information:
  - Caliber/Gauge
  - Manufacturer/Make/Model
  - Serial number
  - Trace Evidence
  - Type of action
  - Safeties
  - Rifling characteristics
  - Barrel length
  - Overall length
  - Weight
  - Trigger pull
  - Test fire details
  - Operating condition
  - Any other information the examiner might find useful

1.2 Serial number restoration Matrix Panel

- A serial number matrix panel may take on many forms and may include the following information:
  - Type of obliteration
  - Method(s) used during restoration
  - Restoration results
  - Any other information the examiner might find useful

1.3 Projectile Matrix Panel

- A projectile matrix panel takes on many forms and may include the following information:
  - Trace Evidence
  - Projectile Caliber
  - Projectile Weight
  - Projectile condition/description
  - Projectile Rifling Characteristics
  - Shot pellet material, characteristics and quantity
  - Slug material and characteristics
  - Shot wad material and characteristics
  - Comparison notes / results
  - Any other information the examiner might find useful

1.4 Fired Cartridge Case Matrix Panel

- A fired cartridge case matrix panel may take on many forms and may include the following information:
  - Cartridge Case Caliber/Designation
  - Head Stamp details
  - Physical condition/design of the cartridge case
  - Classification of firing pin impression
  - Classification of breech face mark/impressions
  - Detail of any additional markings
  - Comparison notes / results
  - Any other information the examiner might find useful

1.5 Ammunition Matrix Panel

- An ammunition matrix panel may take on many forms and may include the following information:
  - Cartridge Case Caliber/Designation
  - Head Stamp details
  - Physical condition of the cartridge case
  - Classification of marks/impressions
  - Detail of any additional markings
  - Any other information the examiner might find useful

1.6 GSR/Distance Determination Matrix Panel

- A GSR matrix panel may take on many forms and may include the following information:
  - Type of clothing
  - Methods and chemicals used during test
  - Any other information the examiner might find useful

1.7 Toolmark / Tool Matrix Panel

- A Toolmark/tool matrix panel may take on many forms and may include the following information:
  - Toolmark Classification
  - Tool details
  - Physical condition of the tool/Toolmark
  - Detail of any additional markings
  - Any other information the examiner might find useful

2.0 EVIDENCE EXAMINATION

2.1 Physical Evidence Examination *{back to table of contents}*

- **Scope**

The primary purpose of these procedures is to establish minimum standards for documenting evidence examined by the Firearm/Toolmark Section. They are to be used in conjunction with all applicable laboratory policies and procedures and proper scientific methodology. The variables involved in forensic science methods prohibit the establishment of a procedures manual extensive enough to apply to all situations, which might occur. These procedures are to serve only as guidelines. Further assistance in determining which procedure to use may be obtained by a search of the scientific, professional, and forensic literature followed by the appropriate validation.

- **Safety**

All firearms should be treated as if loaded. All firearms should be rendered safe. Rendering a firearm safe does not necessarily mean that it must be unloaded. It means that it must be placed in such a condition that it cannot be fired if it is dropped or the trigger accidentally pulled. The position of the safety should be noted if collected at a crime scene. Follow the appropriate safety measures for handling of bio-hazardous and hazardous materials.

- **Related Documents**
  - none

- **Equipment / Materials / Reagents**
  - Digital camera
    Photographs/digital images/portable digital files serve as documentation and description of evidence examined.
  - Etching pencil, scribing tool, or marker
  - Plastic bags, paper envelopes, or appropriate evidence containers

- **Standards, Controls, and Calibration**
  - none

- **Procedure**
  - Retrieve evidence from the evidence storage or evidence custodian. Verify that a chain of custody is maintained.
  - Verify in LIMS that all other processing requests by other laboratory sections have been completed.
  - Document the evidence packaging (such as the nature of seals, labeling, and preservation). This is typically done by using digital images. Marking the external wrapping/packages with the case number and examiner's initials is optional. Open the container (avoid breaking previous seals if possible).
  - Gloves will be worn during examination/handling of all evidence/contents
  - Document any inconsistencies between actual evidence and information on any forms in LIMS (report/notes/images as necessary).
  - Document and describe inner evidence packages as encountered.
    - Visually examine each item for hair/trace, possible latent prints, biological stains, or residues. Care should be taken to preserve trace evidence for analysis by Crime Scene or DNA personnel. If there is reason to believe that specific types of evidence may be found on particular items, other examiners may be requested to assist in the description, collection, and analysis of that material (e.g. hair/fiber, blood, body fluids, residue, etc.).
    - Uniquely and consistently label each item as applicable.
    - Conduct the appropriate analytical/comparative procedure.
  - All exhibits will be re-packaged in the original container if possible. The inner and outer packaging of the evidence is re-sealed in a manner that would detect tampering and prevent deleterious change. All seals are initialed and dated by the examiner.
  - The evidence should be transferred to the evidence storage area, another analyst or section, or evidence custodian. This transfer is recorded in LIMS.

3.0 FIREARMS IDENTIFICATION

3.1 STANDARD FIREARM EXAMINATION METHOD

3.1.1 PHYSICAL EXAMINATION & CLASSIFICATION OF FIREARMS

- **Scope**

The initial examination of any firearm will include the completion of a firearm LIMS entry panel. This LIMS entry panel will include the manufacturing data of the firearm and will serve as a source to document the condition of the firearm as received and any tests performed to or with the firearm.

- **Safety**

This procedure involves potentially hazardous materials, operations and equipment. This procedure does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this procedure to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use. Proper caution must be exercised and the use of personal protective equipment must be considered. Appropriate hearing and eye protection must be worn when applicable.

- **Related Documents**
    - Safe Firearm Handling
    - Pre-Firing Safety Examination
    - Trigger Pull Examination-Trigger Weights
    - Trigger Pull Examination-Spring Gauge
    - Barrel and Overall Length Measurements

- **Equipment / Materials / Reagents**
    - Trigger Pull Weights
    - Trigger Pull Spring Gauges
    - Rulers
    - Balances
    - Digital camera
    - Etching pencil, scribing tool, or marker
    - Plastic bags, Paper Envelopes, or appropriate evidence containers

- **Standards, Controls, and Calibration**

The equipment and/or instrumentation utilized must be properly calibrated/checked as outlined in the Division and Section SOP.

- **Procedure**
    - A firearm LIMS entry panel should be completed as thoroughly as necessary. This may include determining the following:
        - Trace Evidence
        - Caliber/Gauge

    - Manufacturer/Make
    - Model
    - Serial number
    - Type of action
    - Safeties
    - Rifling characteristics
    - Barrel length
    - Overall length
    - Weight
    - Operating condition
    - Trigger pull measurements

- **Interpretation**
  - This examination serves to document the firearm analysis.

- **Literature / Supporting Documentation**
  - Association of Firearm and Toolmark Examiners Glossary, current edition.

3.1.2 Trigger Pull Examination—Static Weights

- **Scope**

One of the examinations conducted on a firearm is determining the trigger pull of a firearm. Trigger pull is defined as the amount of force, which must be applied to the trigger of a firearm to cause sear release. This examination provides information regarding the mechanical operating condition of the firearm. The trigger pull of a firearm can be obtained utilizing static weights, which make contact with the trigger at a point where the trigger finger would normally rest.

- **Safety**

This procedure involves hazardous materials, operations and equipment. This procedure does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this procedure to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use. Proper caution must be exercised and the use of personal protective equipment must be considered. Appropriate hearing and eye protection must be worn when applicable.

- **Related Documents**
  - Physical Examination & Classification of Firearms
  - Safe Firearm Handling
  - Trigger Pull Examination - Spring Gauge

- **Equipment / Materials / Reagents**
  - Standard Trigger Weights

- **Standards, Controls, and Calibration**
  - Standard Trigger Weights must be properly calibrated/checked as outlined in the Division and Section SOP.

- **Procedure**
  - **Single Action Trigger Pull**
    - Ensure that the firearm is unloaded.
    - Cock the firearm.
    - Hold the firearm firmly with the muzzle pointing vertically opposite of gravity (typically upwards)
    - Rest the trigger hook of the standard trigger weight hanger on the trigger where the average finger would normally rest, making sure it is not touching any other part of the firearm, with the weights hanging parallel to the bore of the firearm.
    - Adding weights at each attempt until the sear releases
    - Record the measurement and repeat a minimum of three times, resetting the sear connection after each attempt.
    - Measuring the trigger pull of a rimfire firearm should not be performed on an empty chamber. Place a "dummy" cartridge case in the chamber for each trigger pull. The examiner may also use this process for some centerfire firearms.
  - **Double Action Trigger Pull**
    - Ensure that the firearm is unloaded.
    - Hold the firearm firmly with the muzzle pointing vertically opposite of gravity (typically upwards)
    - Rest the trigger hook of the standard trigger weight hanger on the trigger where the average finger would normally rest, making sure it is not touching any other part of the firearm, with the weights hanging parallel to the bore of the firearm.
    - Add weights until the weights pull the trigger through the double action sequence and the sear releases.
    - Record the measurement and repeat a minimum of three times. For revolvers, consider repeating trigger pull measurements for each cylinder chamber, and note any chamber that alters the trigger pull.
    - Measuring the trigger pull of a rimfire firearm should not be performed on an empty chamber. Place a "dummy" cartridge case in the chamber for each

trigger pull. The examiner may also use this process for some centerfire firearms.

- **Interpretation**

The results acquired are only an approximation and a different technique may lead to a different trigger pull weight. The trigger pull is normally recorded to the nearest quarter-pound weight increment.

- **Literature / Supporting Documentation**
  - Gamboe, Tom, "MAFS Firearms Workshop: Trigger Pull Methods," AFTE Journal, Vol. 18, No. 3, p. 77.
  - Rios, Ferdinand and Thorton, John, "Static vs. Dynamic Determination of Trigger Pull," AFTE Journal, 1984. Vol. 16, No. 3, p. 84.

3.1.3 Trigger Pull Examination— Force Gauge (Spring / Electronic)

- **Scope**

One of the examinations conducted in a firearms identification examination is determining the trigger pull of a firearm. Trigger pull is defined as the amount of force, which must be applied to the trigger of a firearm to cause sear release. This examination can provide vital information regarding the mechanical operating condition of the firearm. The trigger pull of a firearm can be obtained utilizing a spring gauge, which makes contact with the trigger at a point where the trigger finger would normally rest.

- **Safety**

This procedure involves hazardous materials, operations and equipment. This procedure does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this procedure to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use. Proper caution must be exercised and the use of personal protective equipment must be considered. Appropriate hearing and eye protection must be worn when applicable.

- **Related Documents**
  - Physical Examination & Classification of Firearms
  - Safe Firearm Handling
  - Trigger Pull Examination – Trigger Weights

- **Equipment / Materials / Reagents**
  - Spring Gauge

- **Standards, Controls, and Calibration**
  - Spring Gauges must be properly calibrated/checked as outlined in the Division and Section SOP.
- **Procedure**
  - **Single Action Trigger Pull**
    - Ensure that the firearm is unloaded.
    - Cock the firearm.
    - Hold the firearm with the muzzle parallel to the spring gauge.
    - Ensure the Gauge indicator is "zeroed".
    - Rest the trigger hook of the Gauge on the trigger where the average finger would normally rest. Make sure it is not touching any other part of the firearm and the Gauge is parallel to the bore of the firearm.
    - Apply pressure to the Gauge, until the sear releases.
    - Record the measurement and repeat a minimum of three times, resetting the sear connection after each attempt.
    - Measuring the trigger pull of a rimfire firearm should not be performed on an empty chamber. Place a "dummy" cartridge case in the chamber for each trigger pull. The examiner may also use this process for some centerfire firearms.
  - **Double Action Trigger Pull**
    - Ensure that the firearm is unloaded.
    - Hold the firearm with the muzzle parallel to the spring gauge.
    - Ensure the Gauge indicator is "zeroed".
    - Rest the trigger hook of the Gauge on the trigger where the average finger would normally rest. Make sure it is not touching any other part of the firearm and the Gauge is parallel to the bore of the firearm.
    - Apply pressure to the Gauge, until the sear releases.
    - Record the measurement and repeat a minimum of three times. For revolvers, consider repeating trigger pull measurements for each cylinder chamber, and note any chamber that alters the trigger pull.
    - Measuring the trigger pull of a rimfire firearm should not be performed on an empty chamber. Place a "dummy" cartridge case in the chamber for each trigger pull. The examiner may also use this process for some centerfire firearms.

- **Interpretation**

Measurements obtained should be considered approximations given the accuracy limitations of most measuring devices. The trigger pull is normally recorded to the nearest quarter-pound weight increment.

- **Literature / Supporting Documentation**
    - Gamboe, Tom, "MAFS Firearms Workshop: Trigger Pull Methods," AFTE Journal, 1986. Vol. 18, No. 3, p. 77.
    - Rios, Ferdinand and Thorton, John, "Static vs. Dynamic Determination of Trigger Pull," AFTE Journal, 1984. Vol. 16, No. 3, p. 84.

3.1.4 Barrel & Overall Length Measurement of a Firearm

- **Scope**

One of the common procedures conducted in a firearm identification examination is determining the barrel length and in some cases the overall length of a firearm. Barrel length is defined as the distance between the end of the barrel and the face of the closed breechblock or bolt for firearms other than revolvers. On revolvers, it is the overall length of the barrel including the threaded portion within the frame. Barrel length normally should include compensators, flash hiders, etc., if permanently affixed. Overall length of a firearm is defined as the dimension measured parallel to the axis of the bore from the muzzle to a line at a right angle with the axis and tangent at the rearmost point of the butt plate or grip. Removable barrel extensions, poly chokes, flash hiders, etc., are not part of the measured barrel length or overall length. Common firearm dimension measurements for general documentation may be made using a standard measuring device. Any measurements critical to the determinations of possession of a “Short-Barreled Rifle” or “Short-Barreled Shotgun” require the use of a NIST traceable measuring device when the length(s) are apparently greater than and/or less than the legal length by a quarter of an inch (1/4”).

- **Safety**

This procedure involves hazardous materials, operations and equipment. This procedure does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this procedure to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use. Proper caution must be exercised and the use of personal protective equipment must be considered. Appropriate hearing and eye protection must be worn when applicable.

- **Related Documents**
    - Physical Examination & Classification of Firearms

- **Equipment / Materials / Reagents**

The measuring specifications and accuracy for the NIST traceable measuring devices and the certified measuring rods are determined during certification of these devices and can be found in each laboratory’s equipment/instrumentation notebook.

- For Non Critical Measurements:
    - A standard measuring device (e.g., ruler or barrel rod) capable of measurements to $1/32^{nd}$ of an inch.

    - Non-marring barrel dowel
- For Critical Measurements:
    - A NIST traceable or certified measuring device (e.g., ruler or barrel rod) capable of measurements to 1/32nd of an inch.
    - Non-marring barrel dowel
    - MD-36 measuring device

- **Standards, Controls, and Calibration**
    - Rulers and/or tape measurers must be properly certified as outlined in the Division and Section SOP.

- **Procedure**
    - General Measurement Guidelines
        - Remove any muzzle attachments that are not permanent.
        - Use only a non-marring dowel-rod when taking indirect measurements of a barrel.
        - Measurements of Modified/Altered Shotgun/Rifles are considered critical and the MD-36 measuring device will be used. See the MD-36 Instruction Manual for step by step directions of proper usage.

- **Barrel Length**
    - **Indirect Method**
        - Place a non-marring dowel-rod down the barrel and indicate the length of the barrel on the dowel with the stopping device. The measurement will be taken to the muzzle end of the stopping device.
        - Modified/Altered **Shotguns**:

          a) Measure the distance from the breech face to the muzzle, with the action in a closed and locked position. This measurement can be done directly or by placing a non-marring item down the barrel, marking the distance from the breech end of the barrel to the muzzle and measuring this item.

          b) Measurements are acquired from the breech end of the barrel to the longest point of the muzzle end of the barrel on a line parallel to the axis of the bore.

Note: muzzle attachments are not included in the measure unless they are permanently affixed.

          c) This measurement will be recorded in inches.

        - Modified/Altered **Rifles**:

          a) Measure the distance from the breech face to the muzzle, with the action in a closed and locked position. This measurement can be done directly or by placing a non-marring item down the barrel, marking the distance from the breech end of the barrel to the muzzle and measuring this item.

b) Measurements are acquired from the face of the closed breech block or bolt to the longest point of the muzzle end of the barrel on a line parallel to the axis of the bore.

c) This measurement will be recorded in inches.

- Note: muzzle attachments usually are not included in the measure unless they are permanently affixed.
- Measure the length of the dowel to the stopping device.

- **Barrel Length**

  - **Direct Method**
    - When the general description of firearm barrel length measurement meets or exceeds federal regulations.
    - Measure the distance from the breech end of the barrel to the muzzle parallel to the bore.
    - This approximate measurement will be recorded in inches.
    - Pistols, Revolvers (handguns in general)

      a) Measure from the breech end of the barrel to the longest point of the muzzle end of the barrel, including the threaded portion within the frame (excluding the chambers of a cylinder in revolvers).

- **Overall Length**
  - Measure the distance from a line at the rearmost point of the butt plate or grip to the longest point of the muzzle end of the barrel on a line parallel to the axis of the bore (see attached ATF guidelines).
  - Note: muzzle attachments usually are not included in the measure unless they are permanently affixed.

  - **Interpretation**
    - Non-critical measurements obtained are considered approximate.
    - Measurements of the length of the barrel and the overall length of the shotgun/rifle are considered critical only when they are within ± $1/4^{th}$ inch of the statutory requirements" Statutory firearm length requirements are:

      a) Shotgun greater than or equal to 18 inches barrel length and greater than or equal to 26 inches overall length

b) Rifles greater than or equal to 16 inches barrel length and greater than or equal to 26 inches overall length

- Barrel length and overall length will be measured and reported in inches.
- The following critical measurements require a measurement of uncertainty calculation.
  a) Altered/modified barrel length of a shotgun measures between 17¾th & 18¼th inches.
  b) Altered/modified /modified barrel length of a rifle measures between 15¾th & 16¼th inches.
  c) Altered/modified overall length of a shotgun or rifle measures between 25¾th & 26¼th inches.

- **Measurement of Uncertainty Estimation**
  - While other factors were considered (e.g., environmental conditions, analysts & procedure), the greatest source of measurable variability in this procedure can be attributed to three factors: the NIST traceable or certified measurement standard, the analyst's ability to discern the smallest measurable demarcation on the measurement standard (1/32nd of an inch) and the analyst's placement of the measuring rod in the barrel. With the measurement standard accuracy certified within +/- .005" per every 12", the primary source of variability is attributed to the examiners placement of the rod and the ability to visually discern measurements to the nearest 1/32nd of an inch. See Firearms Uncertainty of Measurement document to review additional data.
  - For critical measurements that require an uncertainty of measurement consideration, the examiner's notes must record the serial number of the NIST traceable or certified measuring device used (i.e., ruler or rod).
  - Altered/modified rifle and shotgun overall and barrel length measurements will be recorded in the notes and report. Overall and barrel length measurements will be measured and reported in inches. Measurements that fall into the critical measurement range indicated above will be reported as length with a statement of uncertainty of +/- 1/8th inch at a coverage probability of 99.7%.

- **Literature / Supporting Documentation**

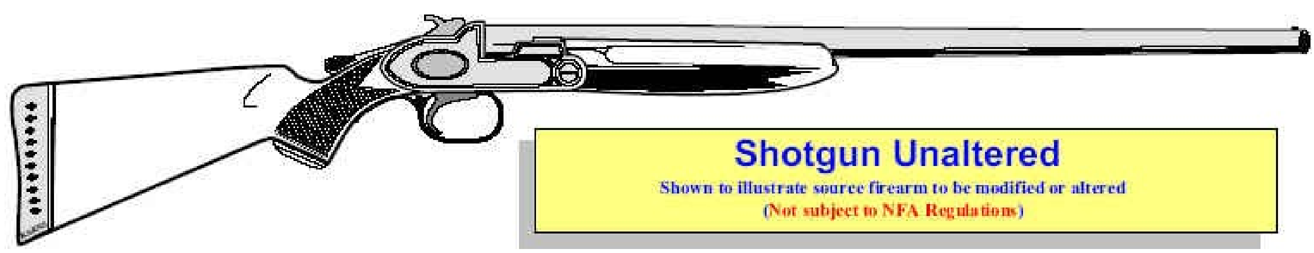
"The Proper Method for Measuring Weapons", AFTE Journal, Vol.14, No. 3, p. 10.

Firearm

26 U.S.C. Chapter 53

For the purposes of the National Firearms Act, the following definitions are used to define and verify the different types of firearms:

§ 5845(d) – The term "SHOTGUN" means a weapon designed or redesigned, made or remade, and intended to be fired from the shoulder, and designed or redesigned and made or remade to use the energy of the explosive in a fixed shotgun shell to fire through a smooth bore either a number of ball shot or a single projectile for each single pull of the trigger.



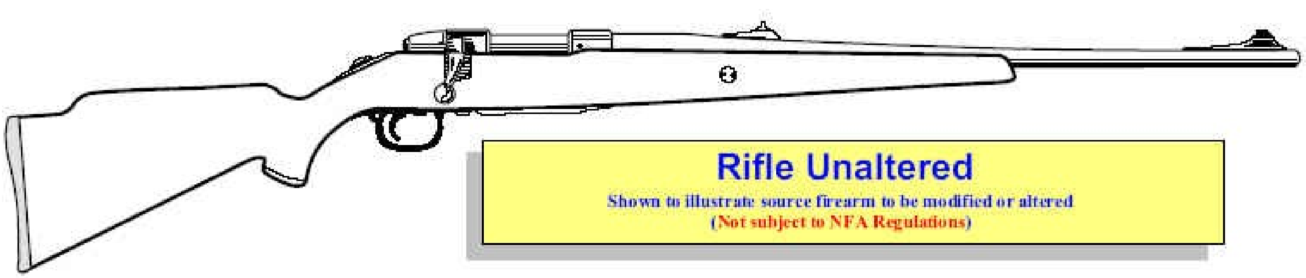
§ 5845(a)(1) – The term "FIREARM" means a shotgun having a barrel or barrels of less than 18 inches in length;

§ 5845(a)(2) – The term "FIREARM" means a weapon made from a shotgun if such weapon as modified has an overall length of less than 26 inches or a barrel or barrels of less than 18 inches in length;

Rifle– 26 U.S.C., § 5485(a)

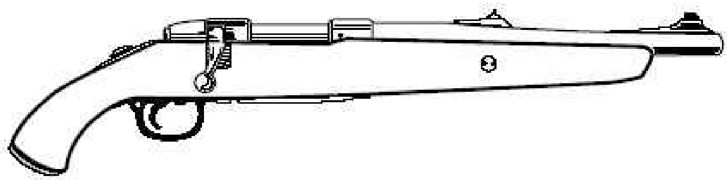
For the purposes of the National Firearms Act, the following definitions are used to define and verify the different types of firearms:

§ 5845(c) – The term "RIFLE" means a weapon designed or redesigned, made or remade, and intended to be fired from the shoulder, and designed or redesigned and made or remade to use the energy of the explosive in a fixed metallic cartridge to fire only a single projectile through a rifled bore for each single pull of the trigger.



§ 5845(a)(3) – The term "FIREARM" means a rifle having a barrel or barrels of less than 16 inches in length;

§ 5845(a)(4) – The term "FIREARM" means a weapon made from a rifle if such weapon as modified has an overall length of less than 26 inches or a barrel or barrels of less than 16 inches in length;



OAL less than 26 inches & Barrel(s) less than 16 inches
Shown with both modified barrel(s) & stock resulting in an Overall Length (OAL) less than 26"
(Weapon made from a Rifle - Subject to NFA Regulations)

THE GUN CONTROL ACT OF 1968 TITLE 18, UNITED STATE CODE, CHAPTER 44

TITLE I : STATE FIREARMS CONTROL ASSISTANCE

Chapter 44 – Firearms

§ 921 Definitions.

(a) As used in this chapter—

(3) The term **"firearm"** means (A) any weapon (including a starter gun) which will or is designed to or may readily be converted to expel a projectile by the action of an explosive; (B) the frame or receiver of any such weapon; (C) any firearm muffler or firearm silencer; or (D) any destructive device. Such term does not include an antique firearm.

(5) The term **"shotgun"** means a weapon designed or redesigned, made or remade, and intended to be fired from the shoulder and designed or redesigned and made or remade to use the energy of an explosive to fire through a smooth bore either a number of ball shot or a single projectile for each single pull of the trigger.
(6) The term **"short-barreled shotgun"** means a shotgun having one or more barrels less than eighteen inches in length and any weapon made from a shotgun (whether by alteration, modification, or otherwise) if such weapon as modified has an overall length of less than twenty-six inches.

(7) The term **"rifle"** means a weapon designed or redesigned, made or remade, and intended to be fired from the shoulder and designed or redesigned and made or remade to use the energy of an explosive to fire only a single projectile through a rifled bore for each single pull of the trigger.

(8) The term **"short-barreled rifle"** means a rifle having one or more barrels less than sixteen inches in length and any weapon made from a rifle (whether by alteration, modification, or otherwise) if such weapon, as modified, has an overall length of less than twenty-six inches.

PENAL CODE TITLE 10.

OFFENSES AGAINST PUBLIC HEALTH, SAFETY, AND MORALS

CHAPTER 46. WEAPONS

Sec. 46.01. DEFINITIONS. In this chapter:

(3) "Firearm" means any device designed, made, or adapted to expel a projectile through a barrel by using the energy generated by an explosion or burning substance or any device readily convertible to that use. Firearm does not include a firearm that may have, as an integral part, a folding knife blade or other characteristics of weapons made illegal by this chapter and that is:

- (A) an antique or curio firearm manufactured before 1899; or
- (B) a replica of an antique or curio firearm manufactured before 1899, but only if the replica does not use rimfire or center fire ammunition.

(10) "Short-barrel firearm" means a rifle with a barrel length of less than 16 inches or a shotgun with a barrel length of less than 18 inches, or any weapon made from a shotgun or rifle if, as altered, it has an overall length of less than 26 inches.

3.2 MISCELLANEOUS FIREARM EXAMINATION METHOD

3.2.1 Rusty Firearm Examination

- **Scope**

Rusty firearms or those found in water, etc. may be submitted for examination. Immediate attention must be given to these firearms to prevent further damage to the firearm. The examiner should instruct the agency recovering the firearm in a fluid such as water, to submit the firearm in a container of the fluid. If this is not practical, the agency can be instructed to immediately and thoroughly spray the firearm with a water-displacing product such as WD-40® or other similar product to prevent further deterioration. It should be noted that the firearm might be too rusted to be functional.

- **Safety**

This procedure involves hazardous materials, operations and equipment. This procedure does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this procedure to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use. Proper caution must be exercised and the use of personal protective equipment must be considered. Appropriate hearing and eye protection must be worn when applicable. Any firearm that cannot be unloaded must be examined in an area designated for firing firearms (preferably a range).

- **Related Documents**
  - Safe Firearm Handling
  - Physical Examination & Classification of Firearms

- **Equipment / Materials / Reagents**
  - Oil (and/or)
  - De-rusting, cleaning solvents

- **Standards, Controls, and Calibration**
  - none

- **Procedure**
  - <u>An examiner must take all necessary steps to ensure that the firearm is unloaded.</u> If it cannot be readily verified to be unloaded it must be examined in an area designated for the firing of firearms. Determining whether or not a firearm is unloaded may necessitate a complete disassembly or in some cases, destruction (e.g. cutting).
  - The examiner must determine to what extent restoring the firearm is necessary (e.g., for test firing, for recovering manufacturer information, serial number, etc.).

- Soak the firearm in penetrating oil, de-rusting solvents or similar material.
- Periodically check the firearm until the firearm functions, or the desired information is recovered.
- Clean the firearm with gun cleaning solvent, cleaning patches and cloth. Care must be taken if any object is placed down the barrel. Only a non-marring item should be placed down the barrel.

- **Interpretation**
  - None

- **Literature / Supporting Documentation**
  - Denio, Dominic, "Making a Rusted Gun Functional," AFTE Journal, 1981. Vol. 13, No. 3, p. 29.

3.2.2 Sound Suppressor Examination

- **Scope**

A silencer or sound suppressor is any device attached to the barrel of a firearm designed to reduce the noise of discharge. Silencers can be commercially produced or homemade. They are typically tubular metal devices, but may vary in shape or form.

- **Safety**

This procedure involves hazardous materials, operations and equipment. This procedure does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this procedure to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use. Proper caution must be exercised and the use of personal protective equipment must be considered. Appropriate hearing and eye protection must be worn when applicable.

- **Related Documents**
  - Safe Firearm Handling
  - Physical Examination & Classification of Firearms
- **Equipment / Materials / Reagents**
  - Sound Meter

- **Standards, Controls, and Calibration**

The sound meter must be properly calibrated/checked as outlined in the Section SOP.

- **Procedure**
  - Testing of a firearm and firearm/silencer combination must be conducted in an appropriate setting, usually a range. In many instances the noticeable reduction in sound between the firing of the firearm with the device attached vs. the firing of

the firearm without the device is sufficient to determine that the device is a sound suppressor.

- ➢ Utilize an appropriate decibel meter or other sound level measuring equipment and follow the manufacturer’s instructions.
- ➢ Document multiple readings with and without the silencer affixed to the firearm when applicable.

- **Interpretation**

The determination can be made that the device is, or is characteristic of, a silencer / muffler or sound suppression device.

- **Literature / Supporting Documentation**
  - ➢ “Silencers - A Review And A Look At The State Of The Art," AFTE Journal, Vol. 23, No. 2, p. 668.
  - ➢ Crum, Richard A. and Owen, Edward M., "Silencer Testing," AFTE Journal, Vol. 21, No. 2, p. 433.

3.2.3 Malfunctioning Firearm Examination

- **Scope**

A firearms examiner may be called upon to examine a firearm to determine if the firearm will malfunction. Many of these cases will deal with the question: "Will the firearm fire without pulling the trigger?" In these instances it should be the goal of the examiner to acquire a detailed account of the incident by thoroughly examining and testing the firearm. Examinations may include external and internal observations or striking or dropping the firearm in attempts to duplicate the incident as reported. The examiner should attempt to conduct his/her examinations in a manner so as not to alter the firearm. However, there may be occasions when damage may occur.

- **Safety**

This procedure involves hazardous materials, operations and equipment. This procedure does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this procedure to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use. Proper caution must be exercised and the use of personal protective equipment must be considered. Appropriate hearing and eye protection must be worn when applicable.

- **Related Documents**
  - ➢ Safe Firearm Handling
  - ➢ Primed Cases

- **Equipment / Materials / Reagents**
  - ➢ Remote firing box

- **Standards, Controls, and Calibration**
  - none

- **Procedure**
  - No one procedure can sufficiently outline the steps necessary to examine all firearms for any malfunction. However, the following list of examinations should serve as a ***guideline*** for the examiner.
    - Physical Check (Condition of Firearm as Received)
      a) Cocked/un-cocked
      b) Safety position
      c) Loaded/unloaded
      d) Cartridge position
      e) Stuck cartridges/discharged cartridge cases
      f) Presence and/or location of flares
      g) If the firearm is to be x-rayed, this may be the time to do it.
    - Visual Abnormalities
      a) Barrel (loose, etc.)
      b) Receiver (condition)
      c) Slide (condition)
      d) Parts broken or missing especially the firing pin, ejector, and/or extractor
      e) Screws (loose or missing)
      f) Alterations or adaptations
      g) Sights
    - Action (External)
      a) Relationships of the action parts
      b) Correct assembly
      c) The proper locking of the action upon closing
      d) Cylinder rotation (securely locks)
      e) Hand relationship to the ratchet (worn)
      f) Trigger (not returning, sticks, broken spring, etc.)
      g) Trigger pull (single action, double action) and striking of hammer.
    - Safeties
      a) ½ cock
      b) Grip
      c) Magazine
      d) Manual levers
      e) Rebound hammer
      f) Inertia firing pin
      g) Condition of safeties
    - Action (External)
      a) Check feeding
        - Magazine

- Carrier or lifter
- Feed ramp
- Magazine lips, etc.

b) Slam fire
c) Extractor and/or ejector markings on evidence cartridges/discharged cartridge cases
d) Unusual marks exhibited on the cartridges/discharged cartridge cases.

- Check for any inherent peculiarities known about the particular firearm based on literature or case data.
- Test Fire Firearm (note operation, misfires, etc.)

a) Consistency of the impression on test and evidence (note any operational problems)
b) Ammunition utilized (proper cartridge, type, reloads, etc.)

- Special Situational Tests:

Attention should be exercised when the force to be used in testing could alter or damage internal parts and their working relationship(s). Damage caused by the examiner may prevent the examiner from determining the cause of the reported malfunction. Conferring with another examiner, the lead investigator or prosecutor prior to any potentially destructive testing is recommended.

- Action (Internal)

a) Hammer notch(s)
   - Worn
   - Burrs
   - Dirt, etc.

b) Sear
   - Worn
   - Broken
   - Burrs, etc

c) Safeties (relationships and general parts relationship)
d) Springs
   - Weak
   - Broken
   - Altered/modified , etc

e) Signs of any tampering or faulty assembly

- **Interpretation**
  - Any change to the firearm must be specifically documented in the examiner's notes.

- **Literature / Supporting Documentation**
  - <u>Association of Firearm and Toolmark Examiners Glossary</u>, current edition.

- Thompson, Roger C., "Firearms Malfunction worksheets," AFTE Journal, 1983. Vol. 15, No. 1, p. 100.
- American National Standards Institute, Inc., “American National Standard Voluntary Industry Performance Standards Criteria for Evaluation of New Firearms Designs Under Conditions of Abusive Mishandling for the Commercial Manufacturers”. (ANSI/SAAMI Z299.5-1985), November, 1985.

3.2.4 Bore Chamber Casting

- **Scope**

Occasionally, firearms are received for which the caliber may not be known or may be different than is designated on the firearm and in the literature. In order to facilitate firing of test shots that are of the correct caliber for a particular firearm, it may be necessary to make a bore and/or chamber cast. Then, by measuring the cast, the correct cartridge can be selected for test firing.

- **Safety**

This procedure involves hazardous materials, operations and equipment. This procedure does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this procedure to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use. Proper caution must be exercised and the use of personal protective equipment must be considered. Appropriate hearing and eye protection must be worn when applicable.

- **Related Documents**
  - Safe Firearm Handling

- **Equipment / Materials / Reagents**
  - Mikrosil®
  - Cerrosafe®
  - WD-40®

- **Standards, Controls, and Calibration**
  - none

- **Procedure**

Casts can be made using various casting materials such as low melting point metals and silicone rubber compounds. The procedure below is for Mikrosil® and Cerrosafe®.
  - Ensure that the firearm is unloaded.
  - Open the action and remove the bolt or bolt assembly.
  - Check the bore to make sure it is clear.
  - Push a cleaning patch in the barrel, from muzzle end, until it is ½ inch to ¼ inch from the beginning of the chamber.

- Lubricate the chamber with gun oil or a silicone spray or some other similar substance such as WD-40®.
- Mix Mikrosil® as per manufacture instructions or melt Cerrosafe® and carefully pour into the chamber until full.
- Do not allow casting material to flow into breech. It will make extraction difficult.
- When casting material is set or cool, depending on type used, gently tap end of cleaning rod to loosen cast from the chamber and remove from the breech.
- If the cast, for some reason, cannot be loosened from the chamber, Cerrosafe® can be melted out of the barrel. This is accomplished by removing the stock and placing breech end in a large container of water and heating to just above its melting temperature.
- Cerrosafe® can be reused as necessary.
- Mikrosil® has to be pushed/forced out and is not reusable. Therefore, it is undesirable to let any more of the casting material than necessary go into the barrel.
- The same steps may be used in the casting of the bore. However in bore casting, only the last three (3) inches of the bore need to be cast.

- **Interpretation**

The correct caliber of the firearm can be determined by measuring the mouth, base, overall length, rim (if pertinent) and shoulder length of the chamber cast, or the diameter of the bore cast.

- **Literature / Supporting Documentation**
  - Striupaitis, Peter P., "Bore Casting Techniques for Caliber Designation of Rifles," AFTE Journal, 1983. Vol. 15, No. 2, p. 88.
  - Poole, Robert A., "Mikrosil Casting Material Information," AFTE Journal, 1983. Vol. 15, No. 2, p. 80.

3.2.5 Firearms Reference Collection

- **Scope**

A Firearms Reference Collection, File or Library is maintained by the laboratory for various scientific reasons, including:

- To identify the make, model and source of evidence firearms.
- To provide exemplar firearms for various scientific testing purposes which might otherwise compromise an evidence firearm.
- To provide an exemplar resource for training new forensic scientists/evidence technicians or in developing new technology for the scientific examination of firearms.
- To provide a source of firearms parts for the temporary repair of evidence firearms for test-firing purposes.

- To provide a resource for the identification of firearms parts recovered at a crime scene.
- To provide a resource for the location and style of firearm serial numbers.

- **Safety**

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

- **Related Documents**
  - Safe Firearm Handling
  - Ammunition Reference Collection

- **Equipment / Materials / Reagents**
  - none

- **Standards, Controls, and Calibration**
  - none

- **Procedure**
  - The procedure for the firearms reference library is located in Chapter 3.14 of the Section SOP.

- **Interpretation**
  - none

- **Literature / Supporting Documentation**

Association of Firearm and Toolmark Examiners Glossary, current edition.

3.2.7 Chronograph

- **Scope**

A chronograph is an electronic device used to measure and record the velocities of projectiles. The chronograph is used to determine the approximate velocity of projectiles fired by both firearms and air guns.

- **Safety**

This procedure involves hazardous operations and equipment. This procedure does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this procedure to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use. Proper caution must be exercised and the use of personal protective equipment such as hearing and eye protection must be used. All firearms should be treated as if loaded.

- **Related Documents**
  - none

- **Equipment / Materials / Reagents**
  - Oehler model 35P chronograph with three skyscreens

- **Standards, Controls, and Calibration**
  - True calibration of a chronograph requires the use of projectiles of known or standardized velocity; however, such "standard" projectiles are not available.
  - The only performance verification that can be made on a chronograph is to check the frequency of the crystal oscillator. The internal crystal oscillation frequency will be certified once every five years.
  - Prior to firing evidence samples, control samples (such as factory loaded ammunition with published muzzle velocities) should be utilized to estimate whether the chronograph is recording velocity measurements similar to expected values.
  - Additionally, if the skyscreens are properly spaced and the system is working properly, the "Proof Velocity" should be very near the "Primary Velocity".

- **Procedure**

Follow the manufacturer's instructions for details on chronograph setup and specific operating instructions. Critical setup instructions are outlined below:

  - Mount the two primary skyscreens at the ends of the 4-foot mounting rail, with the proof skyscreen in the middle. The mounting rail incorporates precisely-spaced indentations to repeatedly position the skyscreens at the correct intervals. Equal spacing of the skyscreens should be verified by direct measurement.
    - *Note: the internal settings of the chronograph can be changed to accommodate different skyscreen spacing; the settings must match the skyscreen spacing, or incorrect velocity measurements will result.*
  - For firearms, the skyscreens should be positioned approximately 8 to 10 feet in front of the muzzle. Interference from muzzle blast, premature triggering of the screens from subsonic projectiles, etc., may dictate an alternate setup.
  - For airguns, the skyscreens can be positioned much closer to the front of the muzzle (1 to 2 feet), as interference from muzzle blast is negligible.
  - For firearms, adjust the height of the skyscreens so the projectile will pass through the approximate center of the skyscreen windows.

- For airguns, adjust the height of the skyscreens so the projectile will pass through the bottom half of the skyscreen windows.
- Indoor use of the chronograph requires the use of auxiliary diffuser-mounted incandescent lights sources.
- Fire through the skyscreen windows. The shot sequence and corresponding velocity measurements are automatically recorded by the chronograph.
- The number of shots fired will vary, depending on the circumstances of the case.
- The velocity measurements are not true "muzzle velocities" but rather the velocity at the midpoint of the skyscreens. Any reported velocity measurements will be designated as ***approximate*** values.

- **Interpretation**
  - Data Collected:
    - The printout from the Model 35P includes:
      a) Proof velocity – Shot number – Primary Velocity
      b) A "statistical summary" of: Highest Velocity ; Lowest Velocity ; Extreme Velocity Spread ; Average Velocity ; Standard Deviation;
      Note: only the "Primary" velocity measurements are summarized.
  - Error Detection:
    - The model 35P incorporates a "Proof channel" to indicate possible setup and measurement errors.
      a) "Primary Velocity" is measured between the first and last screens.
      b) "Proof Velocity" is measured between the first and middle screens.
      c) If the skyscreens are properly spaced and the system is working properly, the "Proof Velocity" should be very near the "Primary Velocity"
    - If there is a significant difference between the "Proof Velocity" and "Primary Velocity" readings, the shot sequence is marked with an asterisk (*) as a possible detection error.
      a) These readings can be omitted from the "Statistical Summary" printout by using the OMIT function; however the data remains in the printed record for later reference.
    - With four-foot screen spacing, velocity differences which trigger the error indication are: 1000 ft/s = +/- 10 ft/s; 2000 ft/s = +/- 21 ft/s; 3000 ft/s = +/- 31 ft/s; 4000 ft/s = +/- 42 ft/s
  - Accuracy:
    - The expected error on any one shot depends on both velocity and screen spacing. With four-foot screen spacing, and assuming proper setup conditions, the manufacturer's stated internal measurement error is:

      1000 ft/s = +/- 1 ft/s; 2000 ft/s = +/- 3 ft/s;
      3000 ft/s = +/- 4 ft/s; 4000 ft/s = +/- 5 ft/s

- **Literature / Supporting Documentation**
  - “Operating Instructions, Model 35P Chronographs”, Oehler Research, Inc. Austin, TX. 1991.

3.2.8 Airguns

- **Scope**

An airgun is a weapon that uses the expanding force of compressed air or gas to propel a projectile. A wide variety of designs exist, varying from simple spring-plunger types, to multi-pump pneumatic types, to CO_2 charged guns. Projectiles propelled through these weapons generally range from .177 to .25 caliber, and vary greatly in weight and design. These projectiles, if driven to sufficient velocities, are capable of causing serious bodily injury or even death in some circumstances.

- **Safety**

This procedure involves hazardous operations and equipment. This procedure does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this procedure to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use. Proper caution must be exercised and the use of personal protective equipment such as hearing and eye protection must be used.

- **Related Documents**
  - Chronograph
  - Physical Examination & Classification of Firearms
  - Safe Firearm Handling
  - Pre-Firing Safety Checks
  - Trigger Pull Examination-Trigger Weights
  - Trigger Pull Examination-Spring Gauge

- **Equipment / Materials / Reagents**
  - Laboratory CO_2 cartridges, if necessary
  - Laboratory BBs or pellets, if necessary

- **Standards, Controls, and Calibration**
  - none

- **Procedure**
  - An airgun examination may share many steps common to a firearm examination, depending on case circumstances. Microscope comparison of lead airgun pellets is often possible. Refer to pertinent procedures, as necessary.

- A LIMS entry panel should be completed as thoroughly as necessary. This may include determining the following:
  - Trace Evidence
  - Caliber
  - Manufacturer/Make/
  - Model
  - Serial number
  - Type of action
  - Safeties
  - Trigger pull
  - Rifling characteristics
  - Barrel length
  - Overall length
- Test-firing:
  - Function testing should be performed simultaneously with chronograph testing.
  - For velocity measurement and performance determinations, the components utilized for test-firing will depend greatly upon the totality of the evidence submitted.
    a) Consideration should be given to:
      - Caliber, weight, and style of any BB's or pellets submitted with the airgun
      - Brand, type, size of any full or depleted CO_2 cartridges submitted with the airgun.
  - If the airgun is submitted <u>without</u> BB's, pellets, or CO_2 cartridges (if applicable), laboratory components will be utilized:
    a) Flat nose "Diablo" style skirted lead airgun pellets are recommended for pellet guns. Excessively light or heavy "specialty pellets" should be avoided for standard testing.
      - Steel BB's are used for smoothbore BB guns.
      - CO_2 cartridges appropriate for the airgun.
      - Document the specifications of any components utilized for testing.
  - For CO_2 powered airguns, consideration should be given to:
    a) Depletion of the CO_2 cartridge may decrease shot-to-shot velocity, depending on the type of internal valve mechanism.
    b) Tests should be performed with a new CO_2 cartridge whenever possible.
    c) Slower shooting may produce more consistent shot-to-shot velocity measurements. Fast consecutive shooting may produce a decrease in the temperature of internal parts, resulting in incrementally lower shot-to-shot velocities.
  - For variable-power and multi-pump pneumatic airguns, consideration should be given to the number of pumps and the effect on performance. If possible,

consult the manufacturer's specifications on maximum number of pumps to avoid damage to the internal mechanisms.
The number of shots fired will be dictated by case circumstances and weapon type. However, it is recommended to fire approximately 10 shots to achieve a statistically significant sampling.

- **Additional information**
  - Any warnings on the airgun should be documented.
  - If the airgun cannot be test-fired, the manufacturer's published muzzle velocities should be obtained whenever possible.

- **Interpretation**

The actual condition of an airgun, as used by the suspect at the time of the alleged crime, can seldom, if ever be accurately determined. Airguns submitted to the laboratory are usually "made safe", which includes releasing the contents of any compressed gas in the weapon. Projectile selection, environmental conditions, and other variables are often beyond the control of the Examiner. Therefore, any function testing, chronograph testing, performance testing, etc. performed in the laboratory is only an example of the general capabilities of the airgun in question.

- **Literature / Supporting Documentation**

  - Galan, J.I. Airgun Digest. 2nd edition, DBI Books, Inc. Northbrook, IL. 1988.
  - Fackler, Martin L. MD; Powley, Kramer D.; Dahlstrom, Dean B.; Atkins, Valerie J.; "Velocity Necessary for a BB to Penetrate the Eye: An Experimental Study Using Pig Eyes," American Journal of Forensic Medicine & Pathology. 25(4):273-275, December 2004.
  - DiMaio, V.J.M. MD; A.R. Copeland, MD ; P.E. Besant-Matthews, MD ; L.A. Fletcher; A. Jones. "Minimal Velocities Necessary for Perforation of Skin by Air Gun Pellets and Bullets". Journal of Forensic Sciences. 27:4 (Oct. 1982) pp. 894-898;
  - DiMaio, Vincent. Gunshot Wounds: Practical Aspects of Firearms, Ballistics, and Forensic Techniques. 2nd edition, 1999.
  - MacPherson, Duncan. Bullet Penetration – Modeling the Dynamics and the Incapacitation Resulting from Wound Trauma. Ballistic Publications, El Segundo, CA. 1994.
  - Noedel, Matthew. "Velocity Drop During the Depletion of CO_2 Cartridges in a Pellet Pistol". AFTE Journal. Vol. 30. No. 3. 1998. pp 435 – 437.
  - Haag, Michael and Haag, Lucien. "Skin Perforation and Skin Simulants". AFTE Journal. Vol. 34, No. 3. 2002. pp 268 – 286.
  - Rathman, Garry A., "The Effect of Shape on BB and Pellet Penetration", AFTE Journal. Vol. 19. No. 4. 1987. pp. 426-431.

- Haag, L.C. and Haag, M.G., "The Exterior Ballistics of Contemporary Air Guns and BB Guns". AFTE Journal. Vol. 30. No. 2. 1998. pp. 262-270.

3.3 Test Firing Method

3.3.1 Water Recovery Tank

- **Scope**

In order to perform a microscopic comparison of a submitted firearm, a minimum of one (1) shot must be fired and recovered. Recovery methods include the Water Recovery Tank, the Cotton Recovery Box, and the Bullet Trap. The type of firearm and ammunition tested will usually dictate the type of recovery method used. The Water Recovery Tank is usually used to recover bullets from handguns, rifles and slugs fired from shotguns.

- **Related Documents**
  - Safe Firearm Handling
  - Remote Firing
  - Downloading
  - Primed Cases

- **Equipment / Materials / Reagents**
  - Water Recovery Tank

- **Standards, Controls, and Calibration**
  - None

- **Procedure**
  - The examiner should consider indexing and sequencing each shot and perform these functions if necessary.
  - Proper hearing and eye protection must be worn.
  - Ensure that the water level is appropriate.
  - Ensure that all lids or doors of the water recovery tank are closed and properly secured.
  - Ensure that the exhaust fans or system is turned on, as applicable.
  - Ensure any warning systems are activated.
  - The examiner should consider loading no more than two (2) cartridges into the firearm during the initial testing of the firearm.
  - Fire the firearm through the shooting port. If the firearm is capable of firing both single and double action modes, a minimum of one (1) shot per mode should be obtained.
  - Recover all of the bullets using a net, pole, or some other appropriate device.

- All ejected discharged cartridge cases must be retrieved. Devices to catch the discharged cartridge cases are commercially available.

- **Interpretation**
  - none

- **Literature / Supporting Documentation**
  - "New Ballistics Tank from Detroit-Armor Corporation Allows Fast Recovery Without Projectile Distortion.", AFTE Journal, Vol. 16, No. 3, p.106.
  - "Bullet and Cartridge Case Recovery", AFTE Journal, Vol. 16, No. 2, p.75.

3.3.2 Cotton Recovery Box

- **Scope**

In order to perform a microscopic comparison of a submitted firearm, a minimum of one (1) test shot must be fired and recovered. Recovery methods include the Water Recovery Tank, the Cotton Recovery Box, and the Bullet Trap. The type of firearm and ammunition tested will usually dictate the type of recovery method used. The Cotton Recovery Box is usually used to recover bullets from handguns, rifles and slugs fired from shotguns.

- **Related Documents**
  - Safe Firearm Handling
  - Remote Firing
  - Downloading
  - Primed Cases

- **Equipment / Materials / Reagents**
  - Cotton Recovery Box

- **Standards, Controls, and Calibration**
  - none

- **Procedure**
  - The examiner should consider indexing and sequencing each shot and perform these functions if necessary.
  - Proper hearing and eye protection must be worn.
  - The examiner should consider wetting the first section of cotton in the box.
  - The examiner should consider the placement of paper partitions at various points in the box to ensure tracking of the test shot, as well as ensuring that the cotton is packed down so as not to retain previous bullet paths.
  - Ensure that all lids or doors of the box are closed and properly secured.

- Ensure that the exhaust fans or system is turned on.
- Ensure any warning systems are activated.
- The examiner should consider loading no more than two (2) cartridges into the firearm during the initial testing of the firearm.
- Fire the firearm through the shooting port. If the firearm is capable of firing both single and double action modes, a minimum of one (1) shot per mode should be obtained.
- Bullets should be recovered by searching through cotton, using partitions as guides.
- Ejected cartridge cases must be retrieved. Devices to catch the discharged cartridge cases are commercially available.

- **Interpretation**
  - none

- **Literature / Supporting Documentation**
  - Newquist, Andrew M., "New Bullet Recovery System", AFTE Journal, February 1973, p.9.
  - Molnar, S., "A Novel Bullet Recovery Method", AFTE Newsletter, 16, p.17.

3.3.3 Bullet Trap

- **Scope**

In order to perform a microscopic comparison of a submitted firearm, a minimum of one (1) test shot must be fired and recovered. Recovery methods include the Water Recovery Tank, the Cotton Recovery Box, and the Bullet Trap. The type of firearm and ammunition tested will usually dictate the type of recovery method used. The Bullet Trap is usually used to test fire firearms when the recovery of the fired projectile(s) is not necessary.

- **Related Documents**
  - Safe Firearm Handling
  - Remote Firing
  - Downloading
  - Primed Cases

- **Equipment / Materials / Reagents**
  - Bullet Trap

- **Standards, Controls, and Calibration**
  - none

- **Procedure**
  - ➢ The examiner should consider indexing and sequencing each shot and perform these functions if necessary.
  - ➢ Proper hearing and eye protection must be worn.
  - ➢ Ensure that the exhaust fans or system is turned on.
  - ➢ Ensure any warning systems are activated.
  - ➢ The examiner should consider loading no more than two (2) cartridges into the firearm during the initial testing of the firearm.
  - ➢ Fire the firearm into the front of the trap. If the firearm is capable of firing both single and double action modes, a minimum of one (1) shot per mode should be obtained.
  - ➢ Ejected cartridge cases must be retrieved. Devices to catch the discharged cartridge cases are commercially available.

- **Interpretation**
  - ➢ none

- **Literature / Supporting Documentation**
  - ➢ McBrayer, William S., "What? Another Water Tank and Bullet Stop!", AFTE Journal, Vol. 10, No. 2, p.90.
  - ➢ "Bullet and Cartridge Case Recovery", AFTE Journal, Vol. 16, No. 2, p.75

3.3.4 Remote Firing

- **Scope**

During the course of examining a firearm, it may be determined that it would be unsafe for the examiner to fire the firearm by holding it as designed. If it is necessary to obtain test standards from this firearm, the firearm should be fired remotely. The remote firing device can be utilized for firing long arms and handguns.

- **Related Documents**
  - ➢ Safe Firearm Handling
  - ➢ Downloading
  - ➢ Primed Cases

- **Equipment / Materials / Reagents**
  - ➢ Remote firing box

- **Standards, Controls, and Calibration**
  - ➢ none

- **Procedure**
  - The examiner should consider indexing and sequencing each shot and perform these functions if necessary.
  - Proper hearing and eye protection must be worn.
  - Set up the chosen remote firing device, as per guidelines set forth by the manufacturer, in front of the appropriate recovery system.
  - Place firearm in device. It is recommended that the examiner first dry-fire the firearm in the remote firing device before using live ammunition.
  - Ensure that the exhaust fans or system is turned on.
  - Ensure any warning systems are activated.
  - The examiner should consider loading no more than one (1) cartridge into the firearm during the initial testing of the firearm.
  - Activate the remote device while standing behind a protective shield or while standing at a safe distance away from the firearm.
  - Obtain fired tests as applicable.

- **Interpretation**
  - none

- **Literature / Supporting Documentation**
  - Biasotti, A. A., "Vise/Rest for Remote Firing," AFTE Journal, 1979. Vol. 11, No. 4, p.16.

3.3.5 Downloading

- **Scope**

Due to the limitations of the Laboratory's bullet recovery devices, it may be necessary to reduce or change the powder load of the cartridge in order to obtain a velocity suitable for safely collecting test standards for comparison purposes. Even with a reduced load, it may be necessary to fire the firearm remotely.

- **Related Documents**
  - Safe Firearm Handling
  - Remote Firing
  - Primed Cases
  - Water Recovery Tank
  - Cotton Recovery Box
  - Bullet Trap

- **Equipment / Materials / Reagents**
  - Inertia bullet puller
  - Reloading press

- Balance/Scale
- Powder charge

- **Standards, Controls, and Calibration**
  - The balance must be properly calibrated/checked as outlined in the Division and Section SOP.

- **Procedure**

CAUTION: 50% downloading CANNOT be used with slow burning powders.
50% downloading CANNOT be used with many non-canister powders.
When utilizing downloaded ammunition it is imperative that the examiner checks the barrel for obstructions between each firing. The bullet, cartridge case, or shotshell of each test shot should be marked appropriately.

- **<u>Method A – replacing the existing powder</u>**
  - Pull the bullet out of the cartridge using an inertia bullet puller or a reloading press.
  - Remove existing powder
  - Weigh the pulled bullet.
  - Consult a reloading manual and obtain the powder charge for the weight of the pulled bullet and the new velocity needed.
  - Weigh out the appropriate powder charge and place in existing cartridge case.
  - Loosely pack a small piece of tissue or other similar material into the case to fill the gap between the bullet and powder.
  - Seat the bullet back into the cartridge case using a rubber mallet or a reloading press.

- **<u>Method B – reusing existing powder</u>**
  - Pull the bullet out of the cartridge using an inertia bullet puller or a reloading press.
  - Remove existing powder and weigh.
  - Replace 60 – 90% of the original powder charge into the cartridge case.
  - Loosely pack a small amount of tissue paper (or similar buffer compound) to fill the voided space.
  - Reseat the bullet into the cartridge case using a rubber mallet or reloading press

- **Interpretation**
  - none

- **Literature / Supporting Documentation**
  - Lyman Reloading Handbook for Rifle, Pistol and Muzzle Loading, Lyman Gun Sight Products, Middlefield, Conn., 1971.
  - "Reduced Powder Loads," AFTE Newsletter, No. 3, p.14.

3.3.7 Primed Cartridge Case/Shotshell

- **Scope**
  - During the course of examining a firearm, it may be determined that it would be unsafe for the examiner to fire the firearm as designed. If it is not necessary to obtain test standards for comparison purposes, the firing condition of the firearm can be tested using a primed empty cartridge case or shotshell.

- **Related Documents**
  - Safe Firearm Handling
  - Bullet Trap

- **Equipment / Materials / Reagents**
  - Inertial bullet pull

- **Standards, Controls, and Calibration**
  - none

- **Procedure**
  - Obtain a primed empty cartridge case in the desired caliber or pull the bullet of a live cartridge using an inertia bullet puller or reloading press, retaining only the primed cartridge case. For shotguns, obtain a primed empty shotshell in the desired gauge or cut open a live shotshell removing all components, retaining only the primed shotshell.
  - Commercial firing pin testing devices are available for shotguns and may be used.
  - Proper hearing and eye protection must be worn.
  - Ensure that the exhaust fans or system is turned on.
  - Ensure any warning systems are activated.
  - Load the primed empty cartridge case, primed empty shotshell or commercial firing pin testing device into the chamber of the firearm and test fire in front of the bullet trap.
  - When utilizing primed empties it is imperative that the examiner checks the barrel for obstructions between each firing.
  - Repeat if the firearm has more than one action.
  - Obtain all tests.

- **Interpretation**
  - none

- **Literature / Supporting Documentation**
  - none

3.4 FIRED EVIDENCE EXAMINATION METHOD

3.4.1 Caliber Determination

- **Scope**

Caliber, or the base diameter, is one of the class characteristics of a fired bullet. The determination of caliber will aid the examiner during the identification or elimination of a suspect firearm. If no firearm is submitted, the bullet's caliber may be used in determining the General Rifling Characteristics of the firearm involved.

- **Related Documents**
  - Trace Material Examination
  - GRC Utilization

- **Equipment / Materials / Reagents**
  - Comparison microscope
  - Stereo microscope
  - Calipers/Micrometer

- **Standards, Controls, and Calibration**
  - The Comparison Microscope, Leica Stage Measurement tool, balances, calipers, and micrometers must be properly calibrated/checked as outlined in the Division and Section SOP.

- **Procedure**
  - The following techniques may be utilized to determine the caliber of any fired bullet. The condition of the bullet will determine which steps can be used.
    - Compare the base diameter of the evidence bullet directly with known fired test standards.
    - Measure the base diameter of the evidence bullet using a caliper or micrometer and compare this measurement with known measurements published in reference literature.
    - Determine the number and widths of the lands and grooves and compare to Appendix G, Table 6, of the AFTE Glossary.
    - Determine the number and widths of the lands and grooves and mathematically calculate the diameter:

$$\mathbf{d = \frac{n * (LIW + GIW)}{3.14}}$$

where **d**= diameter; **n** = number of Lands & Grooves, **LIW**= Land Impression Width; **GIW**= Groove Impression Width;

- Physical characteristics of the evidence bullet, such as weight, bullet shape, composition, nose configuration, and number and placement of cannelures, may aid in caliber determination.

- **Interpretation**
  - Caliber is written as a numerical term and may be depicted with or without the decimal point. If the base is mutilated, the examiner may only be able to determine that the evidence is consistent with a range of calibers or that the caliber cannot be determined.

- **Literature / Supporting Documentation**
  - Mathews, J. Howard, Firearms Identification Vol. I, 1973.
  - Barnes, Frank C., Cartridges of the World, 7th Edition, 1993.
  - Association of Firearm and Toolmark Examiners Glossary, current edition.
  - Lutz, Monty C. and Ward, John G., "Determination of Bullet Caliber From an X-ray," AFTE Journal, Vol. 21, No. 2, p. 168.

3.4.2 Land and Groove Impression Measurement (GRC)

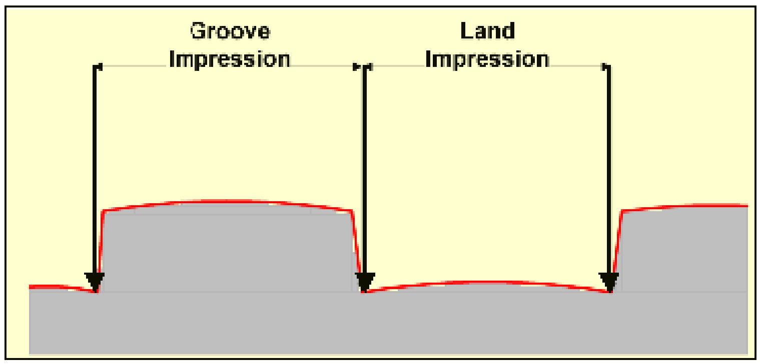
- **Scope**

One of the class characteristics used in the discipline of firearms identification is the width of the land impressions and groove impressions. These measurements aid the examiner during the identification or elimination of a suspect firearm. If no firearm is submitted, these measurements will be used in determining the General Rifling Characteristics of the firearm involved. Several instruments can be used to obtain these measurements.

- **Related Documents**
  - Trace Material Examination
  - GRC Utilization

- **Equipment / Materials / Reagents**
  - Leica FSC Comparison Microscope with Leica Stage Measurement software program
  - Digital Micrometer or Caliper
  - Graduated Stage Micrometer
  - Stereo Microscope

- **Standards, Controls, and Calibration**
  - The Comparison Microscope, Leica Stage Measurement tool, and/or digital micrometer must be properly calibrated/checked as outlined in Division and Section SOP.

- **Procedure**
  - In measuring a fired bullet to determine the width of the land impression or the groove impression, it is paramount that the points used for beginning and ending a measurement comply with the discipline-wide practice. This practice utilizes the anchor points shown below.
    - 

  - Several instruments can be used to measure Land and Groove Impressions.
  - The primary method utilized by the Firearm/Toolmark Section is the Digital Measurement Method using the Leica FSC comparison microscope and a Leica Stage Measurement software program. Other methods may be utilized as necessary; all methods will produce acceptable results.
  - Digital Measurement / Leica Stage Measurement Tool
    - The "Digital Measurement" procedure utilizes a Leica FSC comparison microscope and a Leica Stage Measurement software program
    - The fired bullet in question is mounted on one stage of the comparison microscope. A fixed reference point is mounted on the opposite stage. Both stages must be using the same magnification level (objective setting) and be in focus.
    - Start the Leica Stage Measurement software program
    - Align the fixed reference point with the beginning of a Land Impression. Click the "Left" or "Right" button, followed by the "Start" button on the software interface. Move one of the microscope stages a known distance relative to the stage micrometer. Record the measurement to the nearest thousandth of an inch.
    - Repeat the above utilizing the groove impression.
    - It may be necessary to measure several land and groove impressions in order to record a reliable measurement. Land and groove impression

measurements are typically recorded as a range, indicating maximum and minimum measurements.

- **Air Gap**
  - The Air Gap procedure utilizes a comparison microscope and a digital micrometer or caliper.
    - The fired bullet in question is mounted on one stage of the comparison microscope. The digital micrometer or caliper is mounted on the opposite stage. Both stages must be using the same magnification level (objective setting) and be in focus.
    - Open the jaws of the micrometer to match the anchor points of the land impression and record the measurement to the nearest thousandth of an inch.
    - Repeat the above utilizing the groove impression.
    - It may be necessary to measure several land and groove impressions in order to record a reliable measurement. Land and groove impression measurements are typically recorded as a range, indicating maximum and minimum measurements.

- **Grid / Stage Micrometer**
  - The Grid or Stage Micrometer procedure utilizes a comparison microscope and a graduated stage micrometer.
    - The fired bullet in question is mounted on one stage of the comparison microscope. The graduated stage micrometer is mounted on the opposite stage. Both stages must be using the same magnification level (objective setting) and be in focus.
    - Align the image of the stage micrometer with the image of the appropriate land impression being measured and record the measurement to the nearest thousandth of and inch.
    - Repeat the above utilizing the groove impression.
    - It may be necessary to measure several land and groove impressions in order to record a reliable measurement. Land and groove impression measurements are typically recorded as a range, indicating maximum and minimum measurements.

- **Stereo Microscope - Micrometer**
  - The stereo microscope - Micrometer method procedure utilizes a stereomicroscope and a digital micrometer or caliper.
  - The fired bullet in question is positioned under the stereo microscope.
  - Open the jaws of the micrometer to match the anchor points of the land impression and record the measurement to the nearest thousandth of an inch.
  - Repeat the above utilizing the groove impression.

- It may be necessary to measure several land and groove impressions in order to record a reliable measurement. Land and groove impression measurements are typically recorded as a range, indicating maximum and minimum measurements.

- **Interpretation**
  - Land and groove impressions on damaged bullets may not be visible and/or measurable. While it may not be necessary to take all measurements, it is important to take reliable measurements. Subsequent database searches are dependent on the accuracy of measurements taken.

- **Literature / Supporting Documentation**
  - U.S. Department of Justice, Federal Bureau of Investigation, General Rifling Characteristics File, current edition.
  - Walsh, J. F., "Accuracy, Speed and Conversion in Rifling Measurements," AFTE Journal, Vol. 9, No. 1, p. 50.
  - AFTE Newsletter, No. 4, December 1969, p. 28.

3.4.3 GRC Utilization

- **Scope**

The FBI's General Rifling Characteristics File can be utilized when attempting to determine a list of possible firearms that could have fired an evidence bullet when the correct firearm was not submitted.

- **Related Documents**
  - Land and Groove Impression Measurement (GRC)

- **Equipment / Materials / Reagents**
  - none

- **Standards, Controls, and Calibration**
  - none

- **Procedure**
  - The FBI's General Rifling Characteristics File can be accessed using the most recent version of the PC software version, or the current printout of the file.
  - Alternate databases of rifling data, as well as the Laboratory Reference collection, may also be utilized to supplement the data contained in the FBI database.
  - Follow the operating instructions listed specifically within each of the above systems, utilizing the caliber and general rifling characteristics determined of the evidence bullet.

- Examiners must use their own judgment and discretion in deciding what tolerances and measurement inputs to use, at all times being mindful that the selection of inputs will affect the resulting listing. For typical instances, a tolerance range of 0.003 to 0.005 is adequate; however larger tolerance ranges may be necessary depending on specific circumstances. The GRC File is a flexible tool and Examiner judgment is a proper part of its use.

- **Interpretation**
  - A search of the GRC database will not provide definitive results. The GRC File is designed to aid investigators, not provide a conclusive listing for all possible firearms that could have fired a bullet or cartridge case. How extensive the resulting list of guns one will obtain from a search depends on how restrictive are the measurement inputs.

- **Limitations**
  - Depending on the commonality of class characteristics, or limits of discerning class characteristics, a GRC listing may be so long as to be of no value for the investigator. New or unique rifling characteristics may produce no suitable results.

- **Literature / Supporting Documentation**

  - U.S. Department of Justice, Federal Bureau of Investigation, General Rifling Characteristics File, current year.
  - Walsh, J. F., "Accuracy, Speed and Conversion in Rifling Measurements," AFTE Journal, 1977. Vol. 9, No. 1, p. 50.
  - Molnar, S., “A Simplified Technique for L&G Measurements”, AFTE Newsletter, No. 4, December 1969, p. 28.

3.4.4 Wadding Determination

- **Scope**
  - By examining wadding, the examiner may be able to determine the gauge size, manufacture, and if the wad contains markings suitable for comparison, identification to the firearm that discharged it.

- **Related Documents**
  - Trace Material Examination

- **Equipment / Materials / Reagents**
  - Comparison microscope
  - Stereo microscope
  - Caliper / Micrometer

- **Standards, Controls, and Calibration**
  - Comparison microscope and caliper/micrometer must be properly calibrated/checked as outlined in Division and Section SOP.

- **Procedure**
  - Determine gauge size by;
    - Directly comparing the evidence to the known wadding of similar manufacture, design and composition by comparing the base of evidence to the bases of the standards until a similar size is found.
    - Gauge size can also be determined by measuring the base diameter of the wad with a caliper/micrometer, and comparing these measurements to known measurements or nominal bore diameters.
    - Manufacturer's data can be determined by locating information stamped into the wad or by comparing the wad to known laboratory standards.
    - Microscopic examination may reveal striations suitable for identification of the wad to the shotgun that fired it.
    - If shotshells are submitted for evidence, it may be necessary to disassemble one for the determination of gauge size or manufacture.
    - Record all information on the appropriate LIMS entry panel.

- **Interpretation**
  - Consult known wadding sizes in AFTE Glossary, other reference, or known standards and determine the corresponding type.

- **Limitations**
  - If the wad is mutilated or soaked with blood or other body fluids, the examiner may not be able to specifically determine gauge size. The examiner should also recognize that some manufacturers might duplicate the design of another manufacturer.

- **Literature / Supporting Documentation**
  - <u>Association of Firearm and Toolmark Examiners Glossary</u>, current edition.

3.4.5 Shot Determination

- **Scope**
  - By examining recovered shot pellets, the examiner may be able to determine the actual shot size. The determined size can then be compared to the shot size loaded in submitted live shotshells or to the size that the submitted discharged shotshell was marked to have contained.

- **Related Documents**
  - Trace Material Examination

- **Equipment / Materials / Reagents**
  - Comparison microscope
  - Stereo microscope
  - Caliper / Micrometer
  - Balance / Scale

- **Standards, Controls, and Calibration**
  - Balance, comparison microscope, and caliper/micrometer must be properly calibrated/checked as outlined in Division and Section SOP.

- **Procedure**
  - The examiner may use one or all of the below techniques to determine shot size.
  - **Visual/Microscopic Comparison**
    - Determine the total number of pellets received.
    - Determine the composition of the pellets.
    - Determine the number of pellets suitable for comparison purposes. Make note if pellet sizes all appear to be similar in size. If several different sizes are present, determine each specific size.
    - Record findings on LIMS entry panel.
  - **Comparison by Weight**
    - Record the total number of pellets received.
    - Determine the composition of the pellets.
    - Determine the number of pellets suitable for weighing. Make note if pellet sizes all appear similar. If several sizes present, determine each specific size.
    - Weigh the pellets in grams or grains.
    - Divide weight of pellets by total number weighed.
    - Consult known pellet weights in AFTE Glossary or other reference and determine shot size, which corresponds to evidence shot.
    - Record findings on appropriate LIMS entry panel.
    - The weight of the evidence pellets can also be directly compared to weight of standards using the same number of pellets until a similar known weight is obtained.
  - **Measuring Pellet Size**
    - Determine the total number of pellets received.
    - Determine the composition of the pellets.
    - Determine the number of pellets suitable for comparison purposes. Make note if pellet sizes all appear to be similar in size. If several different sizes are present, determine each specific size.

    - Choose the best specimen and measure diameter using a caliper and record in hundredths or thousandths of an inch or the appropriate measurement.
    - Consult known pellet sizes in AFTE Glossary or other reference and determine shot size, which corresponds to evidence shot.

- **Interpretation**
  - Consult known pellet sizes in AFTE Glossary, other reference, or known standards and determine shot size, which corresponds to evidence shot.

- **Limitations**
  - If the shot is mutilated, the examiner may not be able to specifically determine shot size.

- **Literature / Supporting Documentation**
  - Association of Firearm and Toolmark Examiners Glossary, current edition.

3.4.6 Physical Examination & Classification of Fired Projectiles

- **Scope**
  - The initial examination of any fired bullet evidence will include the completion of a LIMS entry panel. These LIMS entry panels will include the physical description of the fired evidence and will serve as a source to document the condition of the evidence as received and any tests or comparisons performed.

- **Related Documents**
  - Trace Material Examination
  - Caliber Determination
  - Land and Groove Impression Measurement (GRC)

- **Equipment / Materials / Reagents**
  - Comparison microscope
  - Stereo microscope
  - Caliper / Micrometer
  - Balance / Scale

- **Standards, Controls, and Calibration**
  - Balance, comparison microscope, and caliper/micrometer must be properly calibrated/checked as outlined in Division and Section SOP.

- **Procedure**
  - A LIMS entry panel should be completed as thoroughly as necessary. This may include determining the following:

- Any trace material present
- Presence of gunpowder and/or powder imprints adhering to the base
- Caliber
- Weight
- Number of lands and grooves on fired bullet
- Direction of twist
- Measured width of the land impressions
- Measured width of the groove impressions
- Composition of bullet
- Bullet style
- Possible manufacturer/marketer of the bullet/projectile
- A description of the base of the bullet
- Type and position of cannelures
- Any extraneous markings, such as skid marks, shave marks, flared base, and/or other marks
- Condition of the fired evidence as received

➢ Determine and document suitability of the fired evidence for comparison purposes.

- **Interpretation**

This examination serves to document a fired projectile analysis.

- **Supporting Documentation**
  - ➢ Howe, Walter, J., “Laboratory Work Sheets” AFTE Newsletter Number Two, August 1969, p.13.
  - ➢ Association of Firearm and Toolmark Examiners Glossary, current edition.

3.4.7 Physical Examination & Classification of Fired Cartridge Cases

- **Scope**
  - ➢ The initial examination of any fired cartridge case evidence will include the completion of a LIMS entry panel. These LIMS entry panels will include the physical description of the fired cartridge case and will serve as a source to document the condition of the evidence as received and any tests or comparisons performed.

- **Related Documents**
  - ➢ Trace Material Examination

- **Equipment / Materials / Reagents**
  - ➢ Comparison microscope
  - ➢ Stereo microscope

- **Standards, Controls, and Calibration**
  - Comparison microscope must be properly calibrated/checked as outlined in the Division and Section SOP.

- **Procedure**
  - A LIMS entry panel should be completed as thoroughly as necessary. This may include determining the following:
    - Any trace material present
    - Caliber
    - Possible manufacturer/marketer of the item
    - Ignition System (such as Centerfire, Rimfire, or other)
    - Shape of cartridge
    - Description of cartridge case and primer
    - Description of head stamp
    - Description of Firing Pin Impression
    - Description of other markings, to include:
      a) Breech Face Markings
      b) Extractor
      c) Ejector
      d) Resizing Marks
      e) Chamber Marks
      f) Anvil Marks
      g) Magazine Marks
      h) Ejection Port Markings
  - Determine and document suitability of the evidence for comparison purposes.

- **Interpretation**
  - This examination serves to document a cartridge case evidence analysis.

- **Literature / Supporting Documentation**
  - Howe, Walter, J., "Laboratory Work Sheets" AFTE Newsletter Number Two, August 1969, p.13.
  - Association of Firearm and Toolmark Examiners Glossary, current edition.

3.4.8 Physical Examination & Classification of Fired Shotshells

- **Scope**
  - The initial examination of any fired shotshell evidence will include the completion of a LIMS entry panel. These LIMS entry panels will include the physical description of the fired shotshell and will serve as a source to document the condition of the evidence as received and any tests or comparisons performed.

- **Related Documents**
  - Trace Material Examination
  - Physical Examination & Classification of Fired Cartridge Cases

- **Equipment / Materials / Reagents**
  - Comparison microscope
  - Stereo microscope

- **Standards, Controls, and Calibration**
  - Comparison microscope must be properly performance checked as outlined in the Division and Section SOP.

- **Procedure**
  - A LIMS entry panel should be completed as thoroughly as necessary. This may include determining the following:
    - Any trace material present.
    - Gauge/Bore/Caliber
    - Possible manufacturer/marketer of the item
    - Ignition System (such as Centerfire, Rimfire, or other)
    - Shape of shotshell.
    - Description of shotshell and primer
    - Description of head stamp
    - Description of Firing Pin Impression
    - Description of other markings, to include:
      a) Breech Face Markings
      b) Extractor
      c) Ejector
      d) Resizing Marks
      e) Chamber Marks
      f) Anvil Marks
      g) Magazine Marks
      h) Ejection Port Markings
      i) Other Marks
  - Determine and document suitability of the evidence for comparison purposes.

- **Interpretation**
  - This examination serves to document a shotshell evidence analysis.

- **Literature / Supporting Documentation**

  - Howe, Walter, J., “Laboratory Work Sheets” <u>AFTE Newsletter Number Two</u>, August 1969, p.13.
  - <u>Association of Firearm and Toolmark Examiners Glossary</u>, current edition.

3.4.9 Microscopic Comparison

- **Scope**
  - In order for an examiner to identify an item of fired evidence back to the firearm that produced it, a microscopic comparison utilizing a comparison microscope must be performed. The comparison microscope allows the examiner to place the evidence on one side of the microscope and the known standard on the other side. This procedure may also be used to compare two unknown pieces of fired evidence together to determine if they were made by the same firearm.

- **Related Documents**
  - Trace Material Examination
  - Examination & Physical Classification of Fired Bullets
  - Examination & Physical Classification of Fired Cartridge Cases
  - Examination & Physical Classification of Fired Shotshells

- **Equipment / Materials / Reagents**
  - Comparison Microscope
  - Stereo Microscope

- **Standards, Controls, and Calibration**
  - Comparison microscope must be properly performance checked as outlined in the Division and Section SOP.

- **Procedure**
  - The procedure steps below do not have to be performed in the order listed; however, all steps must be considered and/or addressed.
    - Select the correct objective (magnification) setting and ensure that the objectives are locked in place.
    - Select the correct set of oculars (eyepieces).
    - The illumination (lights) used must be properly adjusted. Oblique lighting is usually preferred.
    - If a firearm is included as part of the evidence, compare the test shots produced from this firearm to determine what microscopic characteristics are reproducing.
    - Compare unknown fired evidence to either another piece of unknown fired evidence or a known standard by placing the unknown fired evidence on the left hand stage and the other piece of unknown fired evidence or known standard on the right hand stage.
    - Comparison of the entire unknown should be considered.
    - If an identification is not initially made, the examiner should consider the following factors:

- Angle of lights
- Type of lights
- The need for additional known standards
- The position of the evidence, the tests or both
- The possibility of using magnesium smoke
- The possibility of cleaning the firearm
- The possibility that the firearm itself has changed

➢ Document the results of comparisons including extensive notes and/or photographs on the indexed identification, indexing marks, and general location of the identifying marks.

- **Literature / Supporting Documentation**

➢ Howe, Walter, J., "Laboratory Work Sheets" AFTE Newsletter Number Two, August 1969, p.13.
➢ Association of Firearm and Toolmark Examiners Glossary, current edition.
➢ DeForest, Gaensslen, and Lee, Forensic Science: An Introduction to Criminalistics, McGraw-Hill, New York, 1983.

3.4.10 Trace Material Examination

- **Scope**

➢ Fired evidence recovered during an investigation may contain trace material transferred from the crime scene. This trace material may be in the form of blood, tissue, plaster, paint, hairs, fibers, glass, etc. The examiner needs to evaluate the importance of this evidence and, if further examination of the trace material is necessary, remove and preserve a sample of the trace material present. Removal of trace material may also be necessary to allow the proper examination of the fired evidence.

- **Safety**

NFPA LISTING				
Chemical	**Health Hazard**	**Flammability Hazard**	**Reactivity Hazard**	**Contact Hazard**
15% Acetic Acid	2	2	3	
10% Bleach	2	0	1	
Methanol	1	3	0	
Acetone	1	3	0	

- **WARNING!** Acetone is flammable and can pose a **SEVERE FLAMMABILITY HAZARD.**
- **WARNING!** Methanol is flammable and can pose a **SEVERE FLAMMABILITY HAZARD.**
- **WARNING!** Acetic acid is capable of detonation and can pose a **SEVERE REACTIVITY HAZARD**.

- **Storage Requirements**
  - Chemicals will be stored in the Firearm/Toolmark Lab's designated cabinet or flammable storage container.
  - Chemical storage is located in the workshop area of the laboratory.

- **Related Documents**
  - Microscopic Comparison
  - Examination & Physical Classification of Fired Projectiles
  - Examination & Physical Classification of Fired Cartridge Cases
  - Examination & Physical Classification of Fired Shotshells

- **Equipment / Materials / Reagents**
  - Comparison microscope
  - Stereo microscope
  - Scale / Balance
  - <u>15% Acetic Acid Solution</u>
    Prepare a 15% Acetic Acid Solution with Concentrated Glacial Acetic Acid and distilled water. (Note: always add acid to water. Never add water to acid.)
  - <u>10% Bleach Solution</u>
    Prepare a 10% Bleach Solution with Bleach and distilled water.

- **Standards, Controls, and Calibration**
  - The comparison microscope, Leica Stage Measurement tool, Balances, calipers, and micrometers must be properly calibrated/checked as outlined in the Division and Section SOP.

- **Procedure**
  - Examine the fired evidence visually and microscopically for any trace material and record in notes.
  - Determine if further examination of trace material is necessary.
    - If necessary, consult the appropriate section prior to the removal of any trace evidence.
    - Remove material being careful not to damage the evidence.
    - Place the removed trace material in a suitable container/packaging for submission to the appropriate section for further examination.

- If the trace material is not going to be retained for further examination, proceed with the following steps that are applicable.
  - For evidence containing blood, tissue or other biohazards, soak the evidence for at least one (1) minute in a 10% bleach solution.
  - Remove loose material by rinsing the fired evidence with methanol or water.
  - Remove plaster by rinsing the fired evidence in a 15% acetic acid solution.
  - Remove paint by soaking the fired evidence in alcohol or acetone.

- **Interpretation**
  - It should be documented what steps were performed and the condition of the evidence.

- **Literature / Supporting Documentation**
  - Howe, Walter, J., "Laboratory Work Sheets" AFTE Newsletter Number Two, August 1969, p.13.
  - Association of Firearm and Toolmark Examiners Glossary, current edition.
  - DeForest, Gaensslen, and Lee, Forensic Science: An Introduction to Criminalistics, McGraw-Hill, New York, 1983.

3.4.11 National Integrated Ballistic Information Network – NIBIN

- **Scope**

The National Integrated Ballistics Information Network (NIBIN) is a group of computerized acquisition and comparison stations, set up into regions, across the United States. IBIS BrassTrax is a computerized system for acquiring and transmitting the images of fired cartridge cases into the NIBIN database. This individual characteristic database is considered not as evidence but as examination documentation. The Trax system images the primer/firing pin area of fired cartridge cases using state of the art optical and electronic technology. These images are then stored in databases and sophisticated algorithms are used to correlate the images against each other using filters such as caliber, date of crime and date of entry. These correlations produce lists of possible matches with the highest score at the top of the list. Firearms examiners can then call up the images and compare them side-by-side on a monitor. If a possible association is found during this screening process then the actual evidence to test fire materials or evidence to evidence materials is compared by an examiner utilizing traditional comparative microscopy techniques.

- **Related Documents**
  - Examination & Physical Classification of Fired Cartridge Cases
  - Examination & Physical Classification of Fired Shotshells
  - Microscopic Comparison

- **Equipment / Materials / Reagents**
  - NIBIN/IBIS
  - Comparison microscope
  - Stereo microscope

- **Standards, Controls, and Calibration**
  - The comparison microscope must be properly calibrated/checked as outlined in the Division and Section SOP.

- **Procedure**
  - The NIBIN/IBIS User's Guide should be followed in order to make entries into the system.
  - The examiner must therefore insure that:
    - Criteria for items selected for entry should include fired cartridge cases, shotshells, and bullets.
    - Any evidence bullet selected for entry into NIBIN must have at least one clear and distinct land engraved area and must have sufficient individual characteristics to be able to affect a match.
    - Any evidence cartridge case/ fired shotshell selected for entry into NIBIN must have sufficient individual characteristics within the firing pin impression, ejector and/or within the breech face impressions. These are the areas in which NIBIN correlates for any possible matches.
    - If there is more than one matching evidence bullet(s), shotshell(s), and/or cartridges case(s) suitable for entry into NIBIN, the examiner should select the best one for entry or, if necessary, more than one if different individual characteristics reproduce better on different tests.
  - Any information about the identification of evidence bullets/cartridge cases/fired shotshells to each other and the selection of certain specimens for entry into NIBIN must be documented within the case notes
  - NIBIN Data
    - The computer generates and stores data sheets of all searches and results conducted by this agency.
    - The NIBIN system is maintained and secured by ATF.
    - The data retained in the NIBIN system can be retrieved at anytime by section staff.
    - The data contained in the NIBIN system will be considered part of the firearms case record.

- **Interpretation**
  - Possible links developed from correlations will be confirmed by comparison with actual physical evidence.

- **Limitations**
  - Mutilated or deformed evidence
  - Insufficient markings for inclusion in database

- **Literature / Supporting Documentation**
  - NIBIN/IBIS User's Guide

3.4.12 Digital Image Use and File Management

- **Scope**

Firearms evidence, whenever reasonable, should be documented by producing a visual record of the evidence. One method is by taking digital photographs (images) of the items. Overall photographs of the evidence as received and close-up photos of specific areas on the evidence can serve as detailed documentation of observations. Digital photographs of test targets and serial number restoration progression are examples of items that could also be documented. Digital photographs of comparisons should also be documented whenever reasonable.

- **Related Documents**
  - Physical Examination & Classification of Firearms Evidence

- **Equipment / Materials / Reagents**
  - Digital camera

- **Standards, Controls, and Calibration**
  - none

- **Procedure**
  - The item(s) of evidence should be positioned with adequate lighting in order to get the optimum exposure.
  - The photo(s) will whenever applicable contain a scale in the background.
  - Refer to user manual for instructions on proper use of photographic equipment being utilized.
  - Case related digital images, photographs, and other electronic files will be uploaded to the electronic case file in LIMS either as separate image files associated with the specific case assignment, or imported directly into the notes/LIMS entry panels, whichever is applicable. This image database is considered not as evidence but as examination documentation.
  - Original images downloaded from the camera may be retained as a backup of the LIMS copies, in the event of a network or database failure. These images are typically stored on digital media devices such as external hard drives, CD/DVDs, or network drives.

- All photos taken of evidence will be at the discretion and direction of the examiner performing the analysis.

- **Interpretation**
  - none

- **Literature / Supporting Documentation**
  - none

4.0 RANGE DETERMINATION

4.1 Visual and Microscopic Examination Method

- **Scope**
  - When a firearm is fired, gunshot residues, in the following forms are discharged from the firearm:
    - Burnt gunpowder particles
    - Partially burnt gunpowder particles
    - Unburnt gunpowder particles
    - Vaporous lead
    - Particulate metals
  - These gunshot residues along with the morphology of the bullet hole can effectively be used in determining the possible muzzle to target distance.

- **Related Documents**
  - Microscopic Examination Range Determination

- **Equipment / Materials / Reagents**
  - Stereo microscope

- **Standards, Controls, and Calibration**
  - none

- **Procedure**
  - The visual examination of an item for gunshot residue will include the examination and/or consideration of the following:
    - The presence of vaporous lead (smoke)
    - The presence of particulate metals (shavings of lead, copper, brass)
    - The presence of partially burnt and/or unburnt gunpowder
    - The presence of melted adhering gunpowder
    - A hole in the item
    - The presence of a visible ring around the perimeter of holes

    - The location of all holes, tears, missing buttons, etc.
    - The presence of burning or singeing or melting
    - The presence of any possible masking effects
    - The direction of artifacts surrounding the hole
  - Data regarding these physical effects and visible residues must be included in the examiners notes.

- **Interpretation**
  - **Indications of or consistent with the Discharge of a Firearm**
    - Vaporous Lead (smoke)
    - Particulate Metals (shavings of lead, copper, brass)
    - Unburned Gunpowder (morphology)
    - Melted Adhering Gunpowder
  - **Indications of or consistent with the Passage of a Bullet**
    - A hole in the item
    - Visible ring around the perimeter of holes
    - Location of all holes, tears, missing buttons, etc.
  - **Indications of or consistent with a Contact Shot**
    - Ripping or Tearing
    - Burning or Singeing
    - Melted Artificial Fibers
    - Heavy Vaporous Lead Residues
    - Location of all holes, tears, missing buttons, etc.
  - **Possible Masking Effects**
    - Dark Background Color
    - Blood Staining
    - Intervening Object

  If the above observations support the findings of a “contact shot”, a comparison procedure will be at the discretion of the examiner. If the observations do not support a “contact shot” finding, a working hypothesis will be formed based on the above observations. This hypothesis will be utilized in the comparison procedure.

- **Literature / Supporting Documentation**
  - Anon., (1970). “Gunshot Residues and Shot Pattern Test”, F.B.I. Law Enforcement Bulletin, Vol. 39, No. 9, p.7.
  - Dillon, John, H., “A Protocol for Gunshot Residue Examinations in Muzzle-To-Target Distance Determinations”, AFTE Journal, 1990. Vol.22, No.3, p.32.

4.2 Chemical Examination Method

- **Modified Griess Technique**
  - **Scope**

    The Modified Griess Technique is used independently to detect the presence of nitrites or in conjunction with other tests in range determinations. Its use should be limited to specific areas suspected of, or observed to have, gunshot residues. The Modified Griess test utilizes a color chemistry reaction to help distinguish obscure or faint gunpowder pattern on an object. This test detects nitrites, a product of the incomplete burning of gunpowder. Nitrite residues are exposed to an acetic acid solution and heat to form nitrous acid. The nitrous acid combines with sulfanilic acid in the test medium to form a diazonium compound of sulfanilic acid. The diazonium compound couples with the alpha-naphthol (also in the test medium) to form a bright orange water-soluble azo (nitrogen-bearing) dye. It should be noted that if multiple chemical examinations are going to be performed on an item they must follow a specific order.
    - First - Modified Griess
    - Second - Dithiooxamide
    - Third - Sodium Rhodizonate

  - **Safety**

NFPA Listings				
Chemical	**Health Hazard**	**Flammability Hazard**	**Reactivity Hazard**	**Contact Hazard**
Sulfanilic Acid	3	3	1	CORROSIVE
Alpha-naphthol	3	1	1	
Methanol	1	3	0	
Sodium Nitrite	1	0	0	
Glacial Acetic Acid	1	3	1	

- **WARNING!** Sulfanilic Acid is toxic and can pose a severe health hazard.
- **WARNING!** Sulfanilic Acid is flammable and can pose a severe flammability hazard.
- **WARNING!** Sulfanilic Acid is a strong corrosive and can pose a severe contact hazard.
- **WARNING**! Alpha-naphthol is toxic and can pose a severe health hazard.
- **WARNING!** Methanol is flammable and can pose a severe flammability hazard.
- **WARNING!** Glacial Acetic Acid is flammable and can pose a severe flammability hazard.

- **Storage Requirements**
  - Chemicals will be stored in the Firearm/Toolmark Lab's designated cabinet or flammable storage container
  - Chemical storage is located in the workshop area of the laboratory.
- **Storage Requirements**
  - Sodium Rhodizonate Procedure
  - Dithiooxamide

➢ **Equipment / Materials / Reagents**
  - Scale / Balance
  - Nitrite-free Cheesecloth
  - Reagents:

    a) Sensitized Blank
    - Add 11.6 grains *(0.75 grams)* of Sulfanilic Acid to 150 milliliters of distilled or deionized water and mix.
    - Add 6.5 grains *(0.42 grams)* of Alpha-Naphthol to 150 milliliters of methanol and mix.
    - Once both the solutions in step 1 & 2 are prepared, mix them together in a clean photo tray.
    - Saturate pieces of desensitized photo paper or glossy printer paper in this solution. Filter paper can also be used if photo paper or printer paper is not available.
    - Once the sensitized blanks are dry, store in an airtight plastic container.

    b) Acetic Acid Solution
    - Mix a 15% Glacial Acetic Acid solution in distilled or deionized water.

    c) Nitrite Test Swab/Strip:
    - Dissolve 9.3 grains *(0.6 grams)* of Sodium Nitrite in 100 milliliters of distilled or deionized water.
    - Saturate pieces of filter paper or cotton swabs in this mixture.
    - Store in an airtight plastic container (or prepare fresh)

➢ **Standards, Controls, and Calibration**
  - The Minimum Analytical Standards & Controls for the Modified Griess procedure consists of placing a test mark, utilizing a Nitrite Test Swab/Strip, on one of the sensitized blanks being used. An immediate orange color should appear on the sensitized blank. This color shift indicates that the sensitized blank is sensitive to the presences of nitrites. Document the results of quality testing. If the expected reaction does not occur the reagent will be discarded.

- **Procedure**

  Direct Application Technique: (porous items)
  - Place the evidence face down on the emulsion-coated side of the sensitized blank
  - Using a pencil, index any seams, button holes, buttons, rips, pockets, suspected bullet holes, tears, cuts, etc., for reference.
  - Soak a piece of nitrite free cheesecloth with the acetic acid solution, wring out excess solution, and place over the reverse side of the evidence.
  - Apply heat and pressure with a hot iron, being careful not to melt the paper. Acetic acid steam is forced through the layers, causing the color-producing reaction.
  - Discard the cheesecloth and separate the evidence item from the test paper. Any orange indications on the paper should be photographed.

  Reverse Application Technique: (non-porous items)

  Nonporous or thick surfaces will not permit the passage of the acetic acid-bearing steam through the reaction layers. These materials (e.g., vinyl, wood, sheet metal, thick leather, carpeting, floor tiles, drywall) are not suitable for the direct Modified Griess Test since passage of acetic acid steam is critical to the color-producing reaction.
  - Using a pencil, index any seams, button holes, buttons, rips, pockets, suspected bullet holes, tears, cuts, etc., for reference.
  - Remove the paper and wipe the emulsion-coated side of the test paper with cheesecloth saturated with the acetic acid solution. Lightly apply the solution to the entire surface. (Heavy application may cause indistinct or hazy results.)
  - Place the test paper emulsion side down over the area to be tested, aligning index marks as necessary.
  - Place a piece of filter paper or nitrite free cheese cloth over the back of the treated paper to prevent the iron from sticking to the treated paper.
  - Apply heat and pressure with a hot iron, being careful not to melt the paper.
  - Discard the cheesecloth and separate the evidence item from the test paper. Any orange indications on the paper should be photographed.

- **Interpretation**
  - Any orange, orange-red indications on the paper are the results of the chemically specific test for the presence of nitrite residues. It is possible that a spurious source of nitrite residues (not firearms-related) could be present. These are typically visualized as an orange haze; it is unlikely that such residues would alter the interpretation of the point reactions in a gunshot residue pattern. Occasionally, background reactions can be observed on clothing items made from blue denim and from garments washed using certain detergents. Some disinfectants, as well as marijuana, can yield positive results.

- **Literature / Supporting Documentation**

  - Dillon, J. H. Jr. 1990. The modified Griess test: a chemically specific chromophoric test for nitrite compounds in gunshot residues. AFTE Journal, 22:243-250.
  - Schous, C. E. 1999. A sequence of chemically specific chromophoric tests for nitrite compounds, copper, and lead in gunshot residues. AFTE Journal, 31:3-8.
  - Doyle, Jeffrey S., "Griess Test Modification", AFTE Journal, Vol. 19, no. 2, p. 165.
  - Fiegel, F. and Anger, V., (1972). Spot Tests in Inorganic Analysis, 6th Ed., Elsevier Publishing Co., New York, New York.
  - Anon., (1970). "Gunshot Residues and Shot Pattern Test", F.B.I. Law Enforcement Bulletin, Vol. 39, No. 9, p.7.
  - Dillon, John, H., "A Protocol for Gunshot Residue Examinations in Muzzle-To-Target Distance Determinations", AFTE Journal, Vol.22, No.3, p.32.

- **Dithiooxamide (DTO)** {back to table of contents}

- **Scope**

The Dithiooxamide (DTO) test is used independently to detect the presence of copper or in conjunction with other tests in range determination. The DTO test utilizes a color chemistry reaction to indicate the presence of copper. The DTO test reacts with copper to produce a dark greenish-gray to nearly black color reaction. It should be noted that the DTO test will also react with cobalt, leaving an amber color reaction and nickel, leaving a violet color reaction. This test can effectively be used in identifying copper fragments or copper residue/transfer patterns. Fired bullets making contact with other objects often leave traces of copper at the impact site. This copper transfer comes from the surfaces of a copper containing bullet and/or the barrel of the firearm. This copper transfer can be in the form of minute particles, a fine coating of powder particles or a fine cloud of vaporized copper. At times this copper transfer is an obvious ring or wipe around the hole but is more often invisible.

It should be noted that if multiple chemical examinations are going to be performed on an item they must follow a specific order.

- First- Modified Griess
- Second- Dithiooxamide
- Third- Sodium Rhodizonate

- **Safety**

NFPA Listings				
Chemical	**Health Hazard**	**Flammability Hazard**	**Reactivity Hazard**	**Contact Hazard**
Dithiooxamide	2	1	1	oxy
Ammonia	3	1	0	
Ethanol	0	3	0	

  - **DANGER!** Dithiooxamide is a strong oxidizing agent and can pose an **EXTREME CONTACT HAZARD**.
  - **WARNING!** Ammonia is toxic and can pose a **SEVERE HEALTH HAZARD.**
  - **WARNING!** Ethanol is flammable and can pose a **SEVERE FLAMMABILITY HAZARD.**

- **Storage Requirements**
  - Chemicals will be stored in the Firearm/Toolmark Lab's designated cabinet or flammable storage container.
  - Chemical storage is located in the workshop area of the laboratory.

- **Related Documents**
  - Modified Griess Technique
  - Sodium Rhodizonate Procedure

- **Equipment / Materials / Reagents**
  - Scale / Balance
  - Dithiooxamide Solution:
    a) Prepare a 0.2% Dithiooxamide solution in ethanol.
  - Ammonia Solution:
    b) Prepare a 2:5 ammonia solution in distilled water.

- **Standards, Controls, and Calibration**

The Standards & Controls for the DTO test consists of placing a test mark, utilizing a piece of known copper, on the item to be tested. This test mark must be well away from any holes examined. By performing the DTO procedure on this test mark the examiner can determine if the DTO test reacts positively (greenish-grey) to the copper mark and fails to react in unmarked areas. Document the results of quality testing. If the expected reaction does not occur the reagent will be discarded.

An alternative set of Standards & Controls for the DTO test consists of utilizing cotton swabs dampened with the ammonia solution. One of the treated swabs is rubbed against a piece of known copper. This swab is then processed with the DTO test to insure that the test is reacting properly. Another treated swab is rubbed on the item to be tested. This must be well away from any holes examined. This swab is then processed with the DTO test to insure that the item being tested will not produce a false positive. Document the results of quality testing. If the expected reaction does not occur the reagent will be discarded.

- **Procedure**
  - If the item being tested is a fragment, rub the fragment on a piece of filter paper or cloth and process the test material.
  - Place three drops of the ammonia solution on a piece of filter paper.
  - Place the ammonia treated filter paper over the hole 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 place 3 drops of the Dithiooxamide Solution to the tested area of the filter paper.
  - Repeat this process on all holes to be tested. Both sides of a hole should be tested if there is a question of entrance vs. exit.

- **Interpretation**
  - A dark greenish-gray color reaction, corresponding to the area tested, constitutes a positive reaction for copper.

- **Literature / Supporting Documentation**

  - Schous, C. E. 1999. “A sequence of chemically specific chromophoric tests for nitrite compounds, copper, and lead in gunshot residues.” AFTE Journal, 31:3-8.
  - Lekstrom, J.A. and Koons, R.D., “Copper and Nickel Detection on Gunshot Targets by Dithiooxamide Test”, Journal of Forensic Sciences, Vol. 31, No.4, p. 1283.
  - Steinberg, M., Leist, Y., and Tassa, M., “A New Field Kit for Bullet Hole Identification”, Journal of Forensic Sciences, Vol. 29, No. 1, p. 169.
  - Fiegel, F. and Anger, V., (1972). Spot Tests in Inorganic Analysis, 6th Ed., Elsevier Publishing Co., New York, New York.
  - Anon., (1970). “Gunshot Residues and Shot Pattern Test”, F.B.I. Law Enforcement Bulletin, Vol. 39, No. 9, p.7.

- **Sodium Rhodizonate Technique**
  - **Scope**

    The Sodium Rhodizonate Technique is used independently to detect the presence of lead or in conjunction with other tests in range determinations. The Sodium Rhodizonate Technique utilizes a color chemistry reaction that is specific for lead. It can effectively be used in identifying lead fragments or lead residue/transfer patterns, including the determination of entrance vs. exit bullet holes and bullet impact points. Fired bullets making contact with other objects often leave traces of lead at the impact site. This lead transfer comes from the surfaces of the bullet, the barrel and/or the primer residue. This lead transfer can be in the form of minute particles, a fine coating of powder particles or a fine cloud of vaporized lead. At times this lead transfer is an obvious ring or wipe around a bullet hole but is more often invisible. It should be noted that if multiple chemical examinations are going to be performed on an item they must follow a specific order.

- First - Modified Griess
- Second - Dithiooxamide
- Third - Sodium Rhodizonate

- **Safety**

NFPA Listings				
Chemical	**Health Hazard**	**Flammability Hazard**	**Reactivity Hazard**	**Contact Hazard**
Sodium Rhodizonate	2	0	0	
Hydrochloric Acid	3	0	0	
Sodium Bitartrate	1	0	0	
Tartaric Acid	0	1	0	
Glacial Acetic Acid	2	2	3	

- **WARNING!** Hydrochloric Acid is toxic and can pose a severe health hazard.
- **WARNING!** Glacial Acetic Acid is capable of detonation and can pose a severe reactivity hazard..

- **Storage Requirements**
  - Chemicals will be stored in the Firearm/Toolmark Lab's designated cabinet or flammable storage container.
  - Chemical storage is located in the workshop area of the laboratory.

- **Related Documents**
  - Modified Griess Technique
  - Dithiooxamide

- **Equipment / Materials / Reagents**
  - Scale / Balance
  - Reagents:

- **Sodium Rhodizonate Solution:**
  a) Prepare a saturated solution of Sodium Rhodizonate in distilled or deionized water. The solution is saturated if a slight amount of sediment remains in the beaker after stirring with a glass stirring rod.
- **Hydrochloric Acid Solution:**
  a) Prepare a 5% Hydrochloric Acid solution.
    - Combine 5 mL of concentrated hydrochloric acid with 95 mL of distilled or deionized water. Carefully pour the acid into the water to prevent spattering of acid.
- **Buffer Solution 1:**
  a) Dissolve 29.3 grains *(1.9 grams)* of Sodium Bitartrate and 23.1 grains *(1.5 grams)* of Tartaric Acid in 100 milliliters of distilled or deionized water.
  b) This usually requires both heat and agitation to complete in a reasonable amount of time.
- **Buffer Solution 2**: (used if DTO testing performed, or may be used as an alternative to Buffer Solution 1):
  a) 0.2M Potassium Chloride Solution: Dissolve 11.6 grains *(0.75 grams)* KCl in 50ml distilled or deionized water.
  b) 0.2M Hydrochloric Acid Solution: Dilute 5 ml 12M HCl in 295 ml distilled or deionized water.
  c) KCl Buffer Solution, pH 1.0: Combine 25 ml 0.2M KCl with 67 ml 0.2M HCl.
- **Acetic Acid Solution:**
  a) Prepare a 15% Acetic Acid solution in distilled or deionized water.

➢ **Standards, Controls, and Calibration**

The Standards & Controls for the Sodium Rhodizonate test consists of placing a test mark on the item to be tested, or a secondary item, utilizing a piece of known lead. This test mark must be well away from any suspected bullet defect(s) examined . By performing the Sodium Rhodizonate procedure on this test mark the examiner can determine if the Sodium Rhodizonate solution reacts positively to the lead mark (pink/violet color) and fails to react on an unmarked surface. Document the results of quality testing. If the expected reaction does not occur the reagent will be discarded.

An alternative set of Standards & Controls for the Sodium Rhodizonate test consists of utilizing cotton swabs dampened with a 5% Hydrochloric acid solution. One of the treated swabs is rubbed against a piece of known lead. This swab is then processed with the Sodium Rhodizonate test to insure that the test is reacting properly. Another treated swab is rubbed on the item to be tested. This must be well away from any holes examined. This swab is then processed with the Sodium Rhodizonate test to insure that the item being tested will not produce a false positive. Document the results of quality testing. If the expected reaction does not occur the reagent will be discarded.

- **Procedure**
  - The color of the item to be processed will typically determine whether the Direct Application or Bashinsky Transfer Technique should be utilized. If the item being tested is a fragment, rub the fragment on a piece of filter paper or cloth and process the test material.

  <u>**Direct Application Technique:**</u> *(light colored items)*
  - Spray the Sodium Rhodizonate Solution directly onto the questioned area.
  - Spray the tested area with the appropriate Buffer Solution.
    This solution eliminates the yellow background color caused by the sodium rhodizonate, establishes a pH of 2.8, and displays a pink color in the presence of lead and some other heavy metals.
  - Spray the tested area with the 5% Hydrochloric Acid Solution.
    The pink color fades leaving a blue-violet color, indicating the presence of lead. This result can fade quickly; observations should be photographed and documented promptly.
  - Repeat this process on all holes/areas to be tested. Both sides of a hole should be tested if there is a question of entrance vs. exit.

  <u>**Bashinski Transfer Technique:**</u> *(dark colored items)*
  The Bashinski Transfer Technique is an application of the same chemistry used in the Sodium Rhodizonate Test. It is designed specifically for dark-colored surfaces that may mask the blue-violet coloration of a positive test result.
  - Place a piece of filter paper over the hole/area to be tested. Using a pencil, index any seams, button holes, buttons, rips, pockets, suspected bullet holes, tears, cuts, etc., for reference
  - Remove the filter paper and uniformly dampen it with the 15% Acetic Acid Solution.
  - Re-position the treated filter paper over the hole/area to be tested.
  - Place a second piece of filter paper over the first, apply moderate pressure, and apply a hot iron for approximately 5 seconds or until the paper is dry.
  - Remove both pieces of filter paper and spray the Sodium Rhodizonate Solution onto the tested area of the filter paper.
  - Spray the tested area of the filter paper with the appropriate Buffer Solution.
    This solution eliminates the yellow background color caused by the sodium rhodizonate, establishes a pH of 2.8, and displays a pink color in the presence of lead and some other heavy metals.
  - Spray the tested area of the filter paper with the 5% Hydrochloric Acid Solution.
    The pink color fades leaving a blue-violet color, indicating the presence of lead. This result can fade quickly; observations should be photographed and documented promptly.

- Repeat this process on all holes/areas to be tested. Both sides of a hole should be tested if there is a question of entrance vs. exit.
  Note: Positive blue-violet indications are a mirror image of the lead deposition on the test item.

➢ **Interpretation**

- A violet or purple colored ring corresponding to the margin of the hole, or a violet or purple colored stain corresponding to a transfer/residue pattern in the area tested constitutes a positive reaction for lead. The Sodium Rhodizonate Test is a chemically specific chromophoric test for the presence of lead in any form, including vaporous lead (smoke), particulate lead, lead in primer residues, or lead bullet & shot pellet wipe. The presence of particulate lead is a random non-reproducible phenomenon dependent on many uncontrolled variables that may be caused by leading, metal fouling, or a dirty barrel at the time of discharge. The presence of vaporous lead is very useful in that it typically is found at closer ranges. A positive result around the suspected bullet hole is consistent with passage of a bullet. A positive result on a fragment can indicate it is made of lead or has lead residue on the surface.

➢ **Literature / Supporting Documentation**

- Dillon, J. H., Jr. 1990. The sodium Rhodizonate test: a chemically specific chromophoric test for lead in gunshot residues. AFTE Journal, 22:26-36.
- Schous, C. E. 1999. " A sequence of chemically specific chromophoric tests for nitrite compounds, copper, and lead in gunshot residues." AFTE Journal, 31:3-8.
- Fiegel, F. and Anger, V., (1972). Spot Tests in Inorganic Analysis, 6th Ed., Elsevier Publishing Co., New York, New York.
- Anon., (1970). "Gunshot Residues and Shot Pattern Test", F.B.I. Law Enforcement Bulletin, Vol. 39, No. 9, p.7.
- Dillon, John, H., "A Protocol for Gunshot Residue Examinations in Muzzle-To-Target Distance Determinations", AFTE Journal, Vol.22, No.3, p.32.

4.3 Test Pattern Method

- **Non-Shot Pellet Test Pattern Production**

➢ **Scope**

In order to properly perform a muzzle-to-target range determination examination, it is usually necessary to attempt to reproduce the gunshot residue patterns present on the suspect item. This reproduction is accomplished by shooting tests at varying distances until the gunshot residue pattern present on the suspect item is reproduced. It is an essential prerequisite that the suspect firearm and ammunition consistent with the suspect ammunition be utilized.

- **Related Documents**
  - Shotgun Test Pattern Production Procedure
  - Safe Firearm Handling

- **Equipment / Materials / Reagents**
  - Test Target Media-Attach appropriate size pieces of cotton twill material or a piece of the evidence material to a nitrite free cardboard backing board.

- **Standards, Controls, and Calibration**
  - none

- **Procedure**
  - Tests should be shot one per piece of target media.
  - Tests should be shot in increasing or decreasing range increments until a distance is established, both shorter and longer than, that reproduces the gunshot residue patterns on the suspect item.
  - It is essential that the suspect firearm and appropriate ammunition be utilized for these tests.

- **Interpretation**

  By utilizing the suspect firearm and appropriate ammunition it is possible to obtain a reproduction of a gunshot residue pattern present on a suspect item. Therefore one can ascertain the <u>approximate bracketed</u> distance that particular firearm's muzzle was from the suspect item when it was shot.

- **Literature / Supporting Documentation**
  - Dillon, John, H., "A Protocol for Gunshot Residue Examinations in Muzzle-To-Target Distance Determinations", <u>AFTE Journal</u>, Vol.22, No.3, p.257.
  - Anon., (1970). "Gunshot Residues and Shot Pattern Test", <u>F.B.I. Law Enforcement Bulletin</u>, Vol. 39, No. 9, p.7.

- **Shot Pellet Test Pattern Production**

  - **Scope**

    In order to properly perform a muzzle-to-target range determination examination involving a shotgun, it is usually necessary to attempt to reproduce the shot patterns present on the suspect item. This reproduction is accomplished by shooting tests at varying distances until the shot pattern present on the suspect item is reproduced. It is an essential prerequisite that the suspect firearm and ammunition consistent with the suspect ammunition be utilized.

- **Related Documents**
  - Non-Shot Pellet Test Pattern Production Procedure
  - Safe Firearm Handling

- **Equipment / Materials / Reagents**
  - Test Target Media-Use appropriate size pieces of cotton twill material, a piece of the evidence material, poster board, or heavy paper.

- **Standards, Controls, and Calibration**
  - none

- **Procedure**
  - Tests should be shot one per piece of target media.
  - Tests should be shot in increasing or decreasing range increments until a distance is established, both shorter and longer than, that reproduces the shot patterns on the suspect item.
  - It is essential that the suspect firearm and appropriate ammunition be utilized for these tests.

- **Interpretation**

  By utilizing the suspect firearm and appropriate ammunition it is possible to obtain a reproduction of a shot pellet pattern present on a suspect item. Therefore one can ascertain the approximate bracketed distance that particular firearm's muzzle was from the suspect item when it was shot.

- **Literature / Supporting Documentation**

  - Dillon, John, H. "A Protocol for Shot Pattern Examinations in Muzzle-to-Target Distance Determinations", AFTE Journal, Vol. 23, No. 1, p.49.
  - Dillon, John, H., "A Protocol for Gunshot Residue Examinations in Muzzle-To-Target Distance Determinations", AFTE Journal, Vol.22, No.3, p.257.
  - Anon., (1970). "Gunshot Residues and Shot Pattern Test", F.B.I. Law Enforcement Bulletin, Vol. 39, No. 9, p.7.

5.0 TRAJECTORY ANALYSIS

5.1 Dowel and String Trajectory Method

- **Scope**

The purpose of trajectory analysis is documenting and analyzing evidence involved with shooting incidents. It is primarily used to determine the possible position of the shooter(s).

- **Related Documents**
  - Field notes and photographs

- **Equipment / Materials / Reagents**
  - Dowels, trajectory rods, string, ruler, micrometer, tape measure, calculator, protractor, two-by-four, filter paper of different sizes, ~5% nitric acid solution
  - Laser trajectory kit

- **Standards, Controls, and Calibration**
  - none

- **Procedure**

  Note: Prior to conducting trajectory analysis, the examiner should be briefed on the incident by the investigating officer or through documentation, photos, film, or a combination of these items. It is important that the analyst be aware of the circumstances of the shooting incident so that possible positions of the shooter are not eliminated. A laser trajectory kit may be substituted for the dowel and string or used to supplement the dowel and string methods.
  - Examine the area in and around the hole / holes for possible blood or trace evidence. Photograph, diagram and document all holes prior to removing any evidence or doing any analysis.
  - Examine the hole(s) for characteristics of bullet entry/exit. Document the location and position of the center of the hole(s). Document with photos/sketches as needed.
  - If the Mathematical Trajectory Method will also be used, length and width measurements of the hole(s) should be taken prior to inserting dowels or trajectory rods into the holes.
  - Choose the appropriate diameter dowel or trajectory rod to put into the hole. Find a dowel or rod that is tight but do not force an oversize dowel or rod into the hole.
  - Using a protractor, measure the horizontal and vertical angles of the hole. Document the measurements.
  - Attach a string securely to the dowel or rod and pull the string taut. Ensure the dowel or rod is secured to the surface. Have another analyst or officer walk along the string to ensure that it is tight and that the string is in line with the trajectory of the hole. Have the analyst or officer photograph the trajectory line from different angles. Extend the string along the trajectory line until the possible position(s) of the shooter(s) can be eliminated. For example – at ten feet from the surface struck by the bullet the string is now twelve feet in the air.
  - Document possible positions of the shooter.
    - Measure the distance from the trajectory line to the ground at each of the possible positions.

  - Measure the distance along the ground from possible shooting position(s) to the object with the hole(s).

- **Interpretation**
  - Trajectory analysis is an estimation based on the physical evidence at the scene.
  - The report should reflect a range of possible shooting positions and the reported position(s) and angle(s) are approximations and do not reflect a reconstruction of the sequence of events.

- **Limitations**
  - Possible intermediate targets.
  - The type of surface impacted.

- **Literature / Supporting Documentation**
  - Fisher, Barry A.J., Techniques of Crime Scene Investigation. Florida: CRC, 1993
  - Hueske, Ed, Introduction to Shooting Incident Reconstruction. Personal publication, 1999.
  - Parker, Leroy N., Handout for Shooting Incident Analysis. Personal publication, 1998.

5.2 Mathematical Trajectory Method

- **Scope**

This method is based on the identification of entrance or entrance/exit hole(s), measurements, trigonometry calculations, and assumptions drawn from reports and witness statements. It is primarily used to determine the possible position of the shooter(s).
Note: The measurements for this method must be taken before the insertion of a dowel.
Note: It is highly recommended that the Mathematical Method for entrance and exit holes be corroborated using the Dowel and String Method.

- **Related Documents**
  - Field notes and photographs

- **Equipment / Materials / Reagents**
  - Dowels, string, ruler, micrometer, tape measure, calculator, protractor, two-by-four, filter paper of different sizes, ~5% nitric acid solution
  - Laser trajectory kit

- **Standards, Controls, and Calibration**
  - none

- **Procedure**
  - Initial Examination
    - **Note:** Prior to conducting trajectory analysis, the examiner should be briefed on the incident by the investigating officer or through documentation, photos, film, or a combination of these items. It is important that the analyst be aware of the circumstances of the shooting incident so that possible positions of the shooter are not eliminated. A laser trajectory kit may be substituted for the dowel and string or used to supplement the dowel and string methods.
    - Examine the area in and around the entrance hole / holes for possible blood or trace evidence. Photograph, diagram and document all holes and collect any evidence prior to doing any analysis.
    - Examine the hole(s) for characteristics of bullet entry/exit. Measure the length and width of the entrance hole(s). Document the location and position of the center of the hole(s). Document with photos/sketches as needed.
    - Measure the height of the entrance/exit hole(s) from the ground to the center of the hole.
  - Entrance hole only
    - Determine the angle of impact of the bullet (vertical angle) with the formula:
      a) Vertical angle of impact = arc sin (width of hole / length of hole).

    Note: This may indicate the approximate horizontal distance from a firearm to an object at the time the weapon was fired and not the location of the shooter due to the lack of a horizontal angle of impact.
    - In order to determine the horizontal distance from the object to the muzzle of the firearm at the time the firearm was fired, the approximate height of the firearm from the ground must be known. This can be approximated from information provided by police reports and witness statements. The horizontal distance from a firearm to an object at the time the firearm was fired can then be calculated with the formula:
      a) Horizontal distance from a firearm to an object = (height of the firearm from the ground – height of entrance hole from ground) / tan (vertical angle of impact).
  - Entrance and exit hole
    - Measure the horizontal distance from a fixed reference point (e.g. edge of the wall or door) to the center of the entrance and exit holes.
    - Place a dowel through the entrance and exit hole and mark the dowel on either side of the object. Remove the dowel and measure the distance between the marks. This will tell you the distance the bullet traveled through the object.
    - Calculate the vertical angle, use the formula:
      a) Vertical angle of impact = Arc sin (difference in height of the entrance and exit holes/distance the bullet traveled through object).
    - Calculate the horizontal angle, use the formula:

a) Horizontal angle of impact = Arc cos (difference in horizontal distance of the entrance and exit holes/distance the bullet traveled through object).

- In order to determine the horizontal distance from the object to the muzzle of the firearm at the time the firearm was fired, the approximate height of the firearm from the ground must be known. This can be approximated from information provided by police reports and witness statements. The horizontal distance from a firearm to an object at the time the firearm was fired can then be calculated with the formula:
  a) Horizontal distance from a firearm to an object = (height of the firearm from the ground – height of entrance hole from ground) / tan (vertical angle of impact).
- Document possible position of the shooter by marking off the horizontal distance from the object at the horizontal angle of impact.

- **Interpretation**
  - Trajectory analysis is estimation based on the physical evidence at the scene.
  - The report should reflect a range of possible shooting positions and that the reported position(s) and angle(s) are approximations and do not reflect a reconstruction of the sequence of events.

- **Limitations**
  - Possible intermediate targets.
  - Horizontal distance relies on assumptions drawn from police reports and witness statements.
  - The type of surface impacted.

- **Literature / Supporting Documentation**

  - Fisher, Barry A.J., Techniques of Crime Scene Investigation. Florida: CRC, 1993
  - Hueske, Ed, Introduction to Shooting Incident Reconstruction. Personal publication, 1999.
  - Parker, Leroy N., Handout for Shooting Incident Analysis. Personal publication, 1998.

5.3 Direction of Travel

- **Scope**

  Determining the direction of travel – used when there are intermediate targets such as glass or metal or when there is a ricochet.

  Note: Shooting incidents often involve bullet penetrations through intermediate objects. Some of the more common objects are glass and metal. Sometimes a bullet may not penetrate the object, but may ricochet. The direction of travel can still be determined.

- **Related Documents**
  - Field notes and photographs

- **Equipment / Materials / Reagents**
  - Dowels, string, ruler, micrometer, tape measure, calculator, protractor, two-by-four, filter paper of different sizes, ~5% nitric acid solution
  - Laser trajectory kit

- **Standards, Controls, and Calibration**
  - none

- **Procedure**
  - Penetration
    - Photograph, document, and / or diagram both sides of the surface that has been penetrated by the bullet.
    - If the surface is glass and has not shattered, the direction of travel can be determined by closely observing the "cratering" or "coning". A bullet that has penetrated the glass will produce "cratering" or "coning" on the opposite side of the impact.
    - If the surface is metal, the direction of travel can be determined by closely observing the "cratering" or "coning". A bullet that has penetrated the metal will produce "cratering" or "coning" on the opposite side of the impact.
    - The presence of gunshot residue can be used to confirm the direction of travel.

  - Ricochet
    - Photograph, document, and / or diagram the surface that has been struck by the bullet.
    - If the surface is glass and has not shattered, the direction of travel can be determined by closely observing the "cratering". A bullet that has ricocheted off the glass will produce "cratering" on the same side as the impact.
    - For ricochet off of most surfaces, the shape and depth of the ricochet mark can tell you the direction of travel.
    - Ricochet marks on metal tend to be funnel-shaped. The area where the bullet first strikes the surface is smaller than the area where the bullet exits the surface.
    - Ricochet marks on glass tend to be rounded at the point of entry and small and pointed at the point of exit, showing the direction of travel.
    - For non-frangible surfaces (such as steel), the maximum depth of a ricochet crease is closest to the exit.

    - For frangible surfaces (such as concrete), the maximum depth of a ricochet crease is closest to the entrance.
    - Stress cracks on the underside of painted metal surfaces will point away from the direction of travel in a ricochet, showing the direction of travel.
    - A bullet ricocheting off glass produces a cloud of glass, which travels in the direction of the ricocheting bullet, which can also help determine the direction of travel.
    - Photograph, diagram, and document all relevant information.
    - Bullet creases in painted metal may retain portions of the rifling characteristics of the striking bullet. Document with diagrams and / or photography.
  - Angle of Impact of Ricochet
    - Measure the length and width of the ricochet mark.
    - Determine the angle of impact of the bullet (vertical angle) with the formula:
      a) Vertical angle of impact = arc sin (width of hole / length of hole)

- **Interpretation**

The report should reflect a range of possible shooting positions and that the reported position(s) and angle(s) are approximations and do not reflect a reconstruction of the sequence of events. The type of surface impacted will affect length and width of the ricochet mark.

- **Limitations**
  - Possible intermediate targets.
  - Horizontal distance relies on assumptions drawn from police reports and witness statements.
  - Holes produce by objects propelled at high speeds can be very similar to holes produced by a bullet.
  - The type of surface impacted.

- **Literature / Supporting Documentation**
  - Fisher, Barry A.J., Techniques of Crime Scene Investigation. Florida: CRC, 1993
  - Hueske, Ed, Introduction to Shooting Incident Reconstruction. Personal publication, 1999.
  - Parker, Leroy N., Handout for Shooting Incident Analysis. Personal publication, 1998.

5.4 Ejection Pattern Testing

- **Scope**
  - May be used to determine possible positions of shooter(s) as well as to support the trajectory analysis methods.

- Firearms must always be handled as though loaded.
- The appropriate eye and ear protection is required for test firing.
- Shooting Range Safety Rules.

- **Related Documents**
  - Field notes and photographs

- **Equipment / Materials / Reagents**
  - Dowels, trajectory rods, string, ruler, micrometer, tape measure, calculator, protractor, two-by-four, filter paper of different sizes, ~5% nitric acid solution
  - Laser trajectory kit

- **Standards, Controls, and Calibration**
  - none

- **Procedure**
  - The location and identity of cartridge cases should be established and documented, prior to ejection pattern testing.
  - The approximate shooter position may be approximated based on assumptions drawn from police reports and witness statements.
  - Using a rest (when applicable), test fire the firearm using a full magazine, or loaded to the capacity as dictated by case circumstances. This is already in our version
  - Use a spotter to mark the initial impact location of each cartridge case when applicable. Flags, tents or numbered cards may be used for this purpose. Other items may be used to mark the location of the cartridge cases as obtainable.
  - Locate and mark a position on the ground / surface directly below the ejection port.
  - Measure the X and Y coordinates for the position of each cartridge case. The coordinates are to be measured from the point marked on the ground / surface directly below the ejection port of the weapon that was test fired. Tabulate the results for each and calculate the average for the X and Y coordinate.

- **Interpretation**
  - The report should reflect a range of possible shooting positions and state that the reported position(s) and angle(s) are approximations and do not reflect a reconstruction of the sequence of events.

- **Limitations**
  - Possible intermediate targets
  - Prior to ejection pattern testing, the position of the cartridge cases at the scene must be evaluated. Cartridge cases can strike other objects or surfaces after

being ejected and may come to rest in a position unrelated to a particular firearm's ejection pattern characteristics.
- Some firearms have such erratic ejection patterns that testing may provide no useful information to the investigation.

- **Literature / Supporting Documentation**
  - Fisher, Barry A.J., Techniques of Crime Scene Investigation. Florida: CRC, 1993
  - Hueske, Ed, Introduction to Shooting Incident Reconstruction. Personal publication, 1999.
  - Parker, Leroy N., Handout for Shooting Incident Analysis. Personal publication, 1998.

5.5 Determination of Order of Shots in Glass

- **Scope**
  - May be used to determine which shot occurred first, especially in cases where there are several breaks in glass.

- **Related Documents**
  - Field notes and photographs

- **Equipment / Materials / Reagents**
  - none

- **Standards, Controls, and Calibration**
  - none

- **Procedure**
  - Photograph, diagram, and / or document the initial pane of glass.
  - Observe the radial cracks in the glass. Radial cracks produced by the first incident will either stop by themselves or run to the edges of the glass. Radial cracks from subsequent incidents stop when they meet a crack already present in the glass from an earlier fracture.
  - If the damage is extensive and large portions of the glass have fallen away, the order of the damage can sometimes be determined by fitting the pieces together and analyzing.
  - Document the results of examination.

- **Interpretation**
  - The order of shots may be determined by observation of the patterns.

- **Limitations**
  - Possible intermediate targets.
  - Secondary breakage of glass by other objects.
  - Unknown number of shots.

- **Literature / Supporting Documentation**
  - Fisher, Barry A.J., Techniques of Crime Scene Investigation. Florida: CRC, 1993
  - Hueske, Ed, Introduction to Shooting Incident Reconstruction. Personal publication, 1999.
  - Parker, Leroy N., Handout for Shooting Incident Analysis. Personal publication, 1998.

6.0 TOOLMARK IDENTIFICATION PROTOCOL

6.1 Physical Examination & Classification of Tools and Toolmarks

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- **Scope**
  - Toolmark identification is the microscopic comparison and potential identification of striated or impressed toolmarks as having been made by the same tool. The foundation for this technique is based on the following principles:
    - A tool will bear unique microscopic characteristics due to the manufacturing processes it undergoes, as well as through use and abuse.
    - Tools will generally mark surfaces with which they come in contact with class and individual characteristics.
    - These class and individual characteristics are typically reproducible and identifiable with a particular tool.
  - The initial examination of tools and toolmarks will include the completion of a general laboratory LIMS entry panel. This LIMS entry panel will include the physical description of the tool and toolmarked item. It will also serve as a source to document the condition of the evidence as received and any tests or comparisons performed with the tool.

- **Safety**

NFPA Listings				
Chemical	**Health Hazard**	**Flammability Hazard**	**Reactivity Hazard**	**Contact Hazard**
15% Acetic Acid	2	2	3	
10% Bleach	2	0	1	
Methanol	1	3	0	

Acetone	1	3	0	

- **WARNING!** Acetone is flammable and can pose a **SEVERE FLAMMABILITY HAZARD.**
- **WARNING!** Methanol is flammable and can pose a **SEVERE FLAMMABILITY HAZARD.**
- **WARNING!** Acetic acid is capable of detonation and can pose a **SEVERE REACTIVITY HAZARD**.

- **Storage Requirements**
  - Chemicals will be stored in the Firearm/Toolmark Lab's designated cabinet or flammable storage container.
  - Chemical storage is located in the workshop area of the laboratory.

- **Related Documents**
  - Toolmarks Microscopic Comparison

- **Equipment / Materials / Reagents**
  - Comparison microscope
  - Stereo microscope
  - 15% Acetic Acid Solution:
    Prepare a 15% Acetic Acid Solution utilizing Concentrated Glacial Acetic Acid and distilled water.
  - 10% Bleach Solution:
    Prepare a 10% Bleach Solution utilizing Bleach and distilled water.
  - Test Media (lead, aluminum, etc)
  - Casting material

- **Standards, Controls, and Calibration**
  - **The Standards & Controls for using the above chemicals consists of spot-testing in a discrete area prior to using the cleaning agents on the working surface** to ensure that the chemicals do not react adversely to the working surface. If the chemical begins to cause changes that is believed will impact the actual area of analysis, cease using the chemical and perform another method.

- **<u>Physical Examination & Classification of Tools</u>**

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

- The evidence will be marked in accordance with the Firearm/Toolmark Section SOP.

- A laboratory LIMS entry panel utilized for a tool examination should be filled out, which may include noting the following:
  - The type of tool
  - The brand name of tool
  - The size of the tool
  - The condition of the tool
  - If any trace material is present.
  - The class characteristics of the tool
  - Type of tests conducted
  - The medium used for testing

- **Trace Material Examination (Tools and Toolmarks)**

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

- The evidence will be marked in accordance with the Firearm/Toolmark Section SOP.
- Examine the evidence visually and microscopically for any trace material and record in notes.
- Determine if further examination of trace material is necessary.
  - If necessary, consult the appropriate section prior to the removal of any trace evidence.
  - Remove material being careful not to damage the evidence.
  - Place the removed trace material in a suitable container/packaging for submission to the appropriate section for further examination.
- If the trace material is **not** going to be retained for further examination, proceed with the following steps that are applicable.
  - For evidence containing blood, tissue or other biohazards, soak the evidence for at least one (1) minute in a 10% bleach solution.
  - Remove loose material by rinsing the evidence with methanol or water.
  - Remove plaster by soaking the evidence in a 15% acetic acid solution.
  - Remove paint by soaking the evidence in alcohol or acetone.

- **Physical Examination & Classification of Toolmarks**

In order to compare a questioned toolmark with a suspect tool, it is necessary to evaluate the toolmark. This evaluation will consist of a physical evaluation and classification of the toolmark. This evaluation will help determine what course the rest of the examination should take. The basic objective in evaluating a questioned toolmark is to determine the suitability and classification of the toolmark.

- The evidence will be marked in accordance with the Firearm/Toolmark Section SOP.
- A systematic approach should be used for the physical examination and classification of questioned toolmarks.
- A LIMS entry panel should be completed as thoroughly as necessary. This may include determining the following:
  - If any trace material present.
  - Class of tool that made the toolmark.
  - Major and minor classes of toolmarks
  - Physical characteristics of toolmarks
  - Direction of toolmark.
- Determine and document suitability of the toolmark for comparison purposes. If the toolmark has the same class characteristics as the suspect tool the examination may continue.

- **<u>Tool Test Standards</u>**

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

- A systematic approach should be used for the production of test marks or standards. Consideration should be given to:
  - Areas of recent use on the tool in question.
  - The manner in which the tool acted on a toolmarked surface
  - The direction in which the operating surface of the tool moved. With some tools this may be very limited (bolt cutters); with other tools there may be nearly unlimited directions (a screwdriver).
  - The angle or orientation of the tool relative to the marked surface.
  - The amount of force used on the tool
- The initial test media must be soft enough to prevent alterations of the tool’s working surface. Lead is usually the material utilized. Subsequent tests might require the use of a harder test media to better reproduce the toolmarks.
- Indexing of test standards/ marks: When obtaining test marks, it is important to relate the cut edges or impressions to the corresponding operating surface of the tool by color coding, numbering, or lettering.
- Typically, it is necessary to perform a number of tests to obtain a result that most closely resembles the evidence mark.
- If test toolmark standards are to be compared to casts of toolmarks, any test standards will also have to be cast in order to perform a comparison.
- During/after initial microscopic comparisons, further tests may be necessary.

- **Interpretation**

This examination serves to document a tool / toolmark analysis.

- **Literature / Supporting Documentation**
  - DeForest, Gaensslen, and Lee, Forensic Science: An Introduction to Criminalistics, McGraw-Hill, New York, 1983
  - Association of Firearm and Toolmark Examiners Glossary, current edition.

6.2 Toolmarks Microscopic Comparison

- **Scope**

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

- **Related Documents**
  - Physical Examination & Classification of Tools and Toolmarks
  - Fracture Match/Physical Fit Examination Method

- **Equipment / Materials / Reagents**
  - Comparison microscope
  - Stereo microscope

- **Standards, Controls, and Calibration**
  - none

- **Procedure**

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

- Select the correct objective (magnification) setting and ensure that the objectives are locked in place. Select the correct set of oculars (eyepieces).
- The illumination (lights) used must be properly adjusted. Oblique lighting is usually preferred.
- Compare unknown toolmark to either another unknown toolmark or a known standard by placing the unknown toolmark on the left hand stage and the other unknown toolmark or known standard on the right hand stage.
- The entire toolmark must be considered.
- If an identification is not initially made, the examiner should consider the following factors:
  - Angle of lights
  - Type of lights
  - The need for additional known standards

    - The position of the evidence, the tests or both.
    - The possibility of using magnesium smoke.
    - The possibility of cleaning the tool.
    - The possibility that the tool itself has changed .
  - Document the results of comparisons including extensive notes on the indexed identification, indexing marks, and general location of the identifying marks.

- **Literature / Supporting Documentation**
  - DeForest, Gaensslen, and Lee, Forensic Science: An Introduction to Criminalistics, McGraw-Hill, New York, 1983

6.3 Fracture Match / Physical Fit Examination Method

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- **Scope**

The process of matching two or more objects either through physical, optical, microscopic, or photographic means constitutes a fracture match. At some point, the crystalline grain structure of an object will fail when sufficient force is applied to that object. This failure will occur along the repeating patterns of atoms in the crystal structure of the object. The failure will be random, unique, and microscopically observable. Microscopic examination and comparison permits the examiner to conclude whether the objects were either one entity that was broken, torn, or separated, or were held or bonded together in a unique arrangement. The examination may determine whether or not two or more objects were at one time joined and were a part of the same unit.

- **Related Documents**
  - Toolmarks Microscopic Comparison
  - Casting

- **Equipment / Materials / Reagents**
  - Stereo microscope
  - Comparison microscope
  - Casting materials

- **Standards, Controls, and Calibration**
  - none

- **Procedure**
  - A systematic approach should be used for the fracture match examination, with recording of findings and observations in the notes by documenting and / or photographing the separated items.

- Initial visual inspection of the items submitted may include determining the following:
  - Trace Material
  - Coatings
  - Method of separation
  - Physical composition
  - Color
  - Dimensions of items
  - Pattern
  - Appearance and / or distortions of the separated edges
  - Cross-sectional contours
  - Incidental striations or scratches
  - Extrusion markings
  - Conchoidal fractures
  - Stress lines and hackle marks
- Visually examine the items submitted to determine if they can be physically oriented with one another.
- Microscopically examine the oriented edges using a stereo microscope and a comparison microscope, as appropriate, looking for the presence of corresponding irregularities in the oriented edges.
- Examine both items for the presence of manufacturing marks. Manufacturing marks provide corroborative information that can further support the fracture identification.
- Examine the alignment of the broken edges of both items at ninety degrees to the fractured surface for additional corroboration.
- A cast of one of the separated edges can be made for comparison with the other separated edge using a comparison microscope.
- The Reverse Lighting Technique *(see below)* can be utilized to compare the fractured edges of both questioned specimens.

- **Reverse Lighting Technique:**
  - The fractured surface of each specimen can be made to appear as a mirror image of the other through the use of the reverse lighting technique.
  - Position the two questioned items on the comparison microscope, with the fractured edges facing up
  - Arrange the microscope lights for grazing illumination, one arranged directed from the back of the microscope and one light directed from the front of the microscope.
  - Bring both items into focus at low illumination for a side-by-side comparison.
  - Although the two surfaces are different (high points on one are low points on the other), the shadows generated give the appearance of two **mirror images** across the dividing line of the comparison microscope.

- **Interpretation**

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

- **Literature / Supporting Documentation**

- Orench, Jose A. "A Validation Study of Fracture Matching Metal Specimens Failed in Tension". AFTE Journal. Vol. 37, No. 2, 2005. pp 142-149.
- Katterwe, Horst W. "Fracture Matching and Repetitive Experiments: A Contribution of Validation". AFTE Journal. Vol. 37, No. 3, 2005. pp 229-241.
- Stone, Rocky S. "A Probabilistic Model of Fractures in Brittle Metals". AFTE Journal. Vol. 36, No. 4, 2004. pp 297-301.
- Dixon, K.C. "Positive Identification of Torn Burned Matches with Emphasis on Cross Cut and Torn Fiber comparisons".
- Funk, H.J. "Comparison of Paper Matches." Journal of Forensic Sciences. Vol. 13, No. 1. 1968.
- Glossary of the Association of Firearms and Toolmark Examiners, current edition.
- Kirk, P.L Crime Scene Investigation. 2nd ed. John Wiley & Sons: New York. 1974.
- Saferstein, R. Ed. Forensic Science Handbook. Chapter 4. "Forensic Glass Comparisons". p. 151-153. Prentice-Hall, Inc.: New York. 1982.
- Thorton, John I. "Fractal Surfaces as Models of Physical Matches". Journal of Forensic Sciences. Vol. 31, No. 4, Oct. 1986. p. 1435-1438.
- Van Hoven, H.A. and H.D. Fraysier. "The Matching of Automotive Paint Chips by Surface Striation Alignment". Journal of Forensic Sciences, Vol. 28, No. 2. 1983. p. 463-67.
- Von Bremen, U.G. and L. Blunt. "Physical Comparison of Plastic Garbage Bags and Sandwich Bags". Journal of Forensic Sciences. Vol. 28, No. 3, July, 1983.
- Zugibe, F and J. Costello. "The Jigsaw Puzzle Identification of a Hit and Run Automobile". Journal of Forensic Sciences. Vol. 31, No. 1, 1986. p. 329-32.

6.4 Casting

- **Scope**

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

- **Related Documents**
  - Physical Examination & Classification of Toolmarks
  - Test Standards
  - Toolmarks Microscopic Comparison

- **Equipment / Materials / Reagents**
  - Mikrosil®, Duplicast® or other types of silicon rubber casting material

- **Standards, Controls, and Calibration**
  - none

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

- **Interpretation**
  - None

- **Literature / Supporting Documentation**
  - ANON., "Mikrosil Casting Material Information" AFTE Journal, Vol.15, No. 2, p. 80.
  - Barber, D.C. and Cassidy, F.H., "A New Dimension with 'Mikrosil' Casting Material", AFTE Journal, Vol. 19, No. 3, p.328.

6.5 Magnesium Smoking

- **Scope**

Magnesium smoking is a technique of reducing the glare of a shiny object by lightly coating the surface with fine magnesium smoke. This smoking is traditionally done manually, however a diode sputtering system used for coating Scanning Electron Microscopy (SEM) specimens might also be used.

- **Safety**

NFPA Listings				
Chemical	**Health Hazard**	**Flammability Hazard**	**Reactivity Hazard**	**Contact Hazard**
Magnesium Ribbon	1	4	3	

- **DANGER!** Magnesium Ribbon is highly flammable and can pose an **EXTREME FLAMMABILITY HAZARD.**
- **WARNING!** Magnesium Ribbon is capable of detonation and can pose a **SEVERE REACTIVITY HAZARD.**

- **Storage Requirements**
  - Chemicals will be stored in the Firearm/Toolmark Lab's designated cabinet or flammable storage container.
  - Chemical storage is located in the workshop area of the laboratory.

- **Related Documents**
  - Physical Examination & Classification of Tools and Toolmarks
  - Toolmarks Microscopic Comparison

- **Equipment / Materials / Reagents**
  - Magnesium Ribbon - Cut short strips of magnesium ribbon off the roll.
  - Diode Sputtering System (if used)

- **Standards, Controls, and Calibration**
  - none

- **Procedure**
  - The short pieces of magnesium ribbon are lit.
  - The object to be smoked is passed over the smoke generated by the burning magnesium.
  - If the object collects too much smoke, wipe the smoke off and repeat the process.
  - The coating should be light enough to see the color of the item smoked through the coating of smoke.

- **Interpretation**
  - none

- **Literature / Supporting Documentation**
  - Janneli, R., and Geyer, G., "Smoking a Bullet", AFTE Journal, Vol. 9, No. 2, p. 128.

7.0 SERIAL NUMBER RESTORATION METHOD

7.1 Polishing

- **Scope**
  - Many valuable items manufactured today have serial numbers for identification. These numbers are usually die stamped. This process produces a compression of the metal or plastic in the area immediately surrounding and a short distance below the penetration of the die. Serial numbers are removed and/or obliterated in a variety of ways. The serial number may be restored if the removal/obliteration is not taken past the previously mentioned compression zone. It is desirable to remove (polish) the grinding and filing scratches introduced during obliteration. The Polishing procedure can be effective independently but is more often used in conjunction with various chemical or heat restoration procedures.

- **Related Documents**
  - Chemical Restoration
  - Electrochemical Restoration
  - Magnetic
  - Heat

- **Equipment / Materials / Reagents**
  - Dremel type tool with a sanding/polishing disc
  - Fine grit sand paper.

- **Standards, Controls, and Calibration**
  - none

- **Procedure**
  - Perform an initial inspection of the serial number area for coatings, trace material, any character remnants, and general method of obliteration.
  - Consult current ATF Serial Number Structure Guide and/or laboratory Firearm Reference Collection to assist in determining possible serial number format.
  - Note and record any visible characters prior to polishing.
  - Polish the area of the obliteration using:
    - Dremel type tool with a sanding/polishing disc
    - Deburring wheel
    - Fine grit sand paper
    - Steel wool.
  - Depending on the extent of the obliteration, continue polishing until the surface is mirror-like removing all scratches. If the obliteration is severe it may not be possible or desirable to remove all the scratches.
  - If any characters become visible note these characters.

- If characters do not become visible, proceed to the appropriate chemical or heat restoration procedure.

- **Interpretation**
  - Interpretation of results would include full restoration, partial restoration, or unsuccessful restoration. A full restoration would be a total recognition of all obliterated characters. A partial restoration would be recognition of all obliterated characters less than the total being sought. An unsuccessful restoration would be no recognition of any obliterated characters. Notes should include if the restoration procedure was full, partial, or unsuccessful.

- **Literature / Supporting Documentation**
  - Treptow, Richard, S., Handbook of Methods for the Restoration of Obliterated Serial Numbers, NASA, 1978.
  - Polk, Donald, E. and Giessen, Bill, C. "Metallurgical Aspects of Serial Number Recovery", AFTE Journal, Vol. 21, No. 2, p.174.
  - Bureau of Alcohol, Tobacco and Firearms Laboratory, Serial Number Restoration Handbook, 1999.

7.2 Chemical Restoration

- **Scope**
  - Many valuable items manufactured today have serial numbers for identification. These numbers are usually die stamped. This process produces a compression of the metal or plastic in the area immediately surrounding and a short distance below the penetration of the die. Serial numbers are removed and/or obliterated in a variety of ways. The serial number may be restored if the removal/obliteration is not taken past the previously mentioned compression zone. The chemical restoration procedure or sometimes referred to as the chemical etching procedure is suitable for restoration of serial numbers in metal. The die stamping process is a form of "cold-working" metal. A side effect of cold working is the decrease of that item's ability to resist chemical attack. Therefore the utilization of chemical etching will affect the compressed area of the obliterated number faster and to a greater degree than the non cold-worked area surrounding it. This procedure, in conjunction with the polishing procedure, is an effective way to restore an obliterated serial number in metal.

- **Safety**

NFPA Listings				
Chemical	**Health Hazard**	**Flammability Hazard**	**Reactivity Hazard**	**Contact Hazard**
Cupric Chloride	3	0	0	
Hydrochloric Acid	3	0	0	
Ethyl Alcohol	0	3	0	
Nitric Acid	3	0	0	OXY
Ferric Chloride	2	0	0	
Sodium Hydroxide	3	0	1	

  - **WARNING!** Chloride is toxic and can pose a **SEVERE HEALTH HAZARD.**
  - **WARNING!** Hydrochloric Acid is toxic and can pose a **SEVERE HEALTH HAZARD.**
  - **WARNING!** Nitric Acid is toxic and can pose a **SEVERE HEALTH HAZARD.**
  - **WARNING!** Nitric Acid is a strong solvent possessing oxidizing properties that can pose a **SEVERE HEALTH HAZARD.**
  - **WARNING!** Sodium Hydroxide is toxic and can pose a **SEVERE HEALTH HAZARD.**
  - **WARNING!** Ethyl Alcohol is highly flammable and can pose a **SEVERE SAFETY HAZARD.**
  - NOTE: ALWAYS ADD ACID TO WATER. NEVER ADD WATER TO ACID.

- **Storage Requirements**
  - Chemicals will be stored in the Firearm/Toolmark Lab's designated cabinet or flammable storage container .
  - Chemical storage is located in the workshop area of the laboratory.

- **Related Documents**
  - Polishing
  - Electrochemical Restoration
  - Magnetic
  - Heat

- **Equipment / Materials / Reagents**
  - Scale/Balance
  - Etchants
  - **<u>Fry's Reagent</u>**
    45 grams Cupric Chloride ($CuCl_2$)
    60 ml Hydrochloric Acid (HCl)
    50 ml distilled water (H_20)

- **<u>Turner's Reagent</u>**
  2.5 grams Cupric Chloride ($CuCl_2$)
  40 ml Hydrochloric Acid (HCl)
  25 ml Ethanol
  30 ml distilled water (H_20)
- **<u>Davis Reagent</u>**
  5 grams Cupric Chloride ($CuCl_2$)
  50 ml Hydrochloric Acid (HCl)
  50 ml distilled water (H_20)

- **<u>25% Nitric Acid</u>**
  25 ml Nitric Acid (HNO_3)
  75 ml distilled water (H_20)
- **<u>10% Nitric Acid</u>**
  10 ml Nitric Acid (HNO_3)
  90 ml distilled water (H_20)
- **<u>Acidic Ferric Chloride</u>**
  25 grams Ferric Chloride ($FeCl_3$)
  25 ml Hydrochloric Acid (HCl)
  100 ml distilled water (H_20)
- **<u>Ferric Chloride</u>**
  25 grams Ferric Chloride ($FeCl_3$)
  100 ml distilled water (H_20)
- **<u>25% Hydrochloric Acid</u>**
  25 ml Hydrochloric Acid (HCL)
  75 ml distilled water (H_20)
- **<u>10% Hydrochloric Acid</u>**
  10 ml Hydrochloric Acid (HCL)
  90 ml distilled water (H_20)
- **<u>Griffin's Reagent</u>**
  10 grams Cupric Chloride ($CuCl_2$)
  10 ml Hydrochloric Acid (HCL)
  10 ml distilled water (H_20)
  40 ml methanol
- **<u>Zinc Alloy Etching Reagent(s)</u>**
  Solution 1:
    98 milliliters Phosphoric Acid (H_3PO_4)
    2 ml distilled water (H2O)
  Solution 2:
    5 milliliters Nitric Acid (HNO_3)
    95 ml distilled water (H_2O)
- **<u>10% Sodium Hydroxide</u>**
  10 grams Sodium Hydroxide (NaOH)

100 ml distilled water (H_2O)

- **Standards, Controls, and Calibration**
  - The Standards & Controls for serial number chemical/electro-chemical restoration methods consists of spot testing each reagent to establish efficacy on the item surface or a known metal standard prior to each use. The reagents should create a visible reaction (bubbling, change of color, etc.) on the metallic surfaces if they are working properly. Discard any reagent that fails to react properly and immediately rinse off reagents that appear to over-react.

- **Procedure**
  - Perform an initial inspection of the serial number area for coatings, trace material, any character remnants, and general method of obliteration.
  - Consult current ATF Serial Number Structure Guide and/or laboratory Firearm Reference Collection to assist in determining possible serial number format.
  - Utilize the “Polishing Procedure” if necessary.
  - Determine the serial number medium’s physical properties, e.g. magnetic or non-magnetic. If possible, determine the specific metal alloy (ie. zinc, aluminum, stainless steel, etc.)
  - Choose the appropriate chemical reagent based on the physical properties of the metal. Some metal alloys may not be reactive to the reagents listed below.
  - Spot test the reagent in a discrete area away from the obliteration. Immediately rinse off any reagent that appears to over-react. Document the results.
  - Apply the chemical solution to the area of obliteration utilizing cotton tip applicators or swabs that have been moistened with the chemical solution.
  - If any characters become visible, note these characters.
  - If characters do not become visible, proceed to another appropriate restoration procedure.

Magnetic Media
Fry’s Reagent
Turner’s Reagent
Davis Reagent
10% or 25% Nitric Acid
Acidic Ferric Chloride
Griffin’s Reagent

Non-Magnetic Media
Zinc Alloy Reagent(s)
10% Sodium Hydroxide
Ferric Chloride
10% or 25% Nitric Acid
Acidic Ferric Chloride

Zinc Alloys:
Zinc Alloy Reagents
10% or 25% Nitric Acid

Steel Alloys
Fry's Reagent
Davis Reagent
Turner's Reagent
25% Nitric Acid

Aluminum Alloys
10% Sodium Hydroxide
10% or 25% Nitric Acid
Ferric Chloride
Acidic Ferric Chloride
Dilute Davis Reagent

Stainless Steel:
Fry's Reagent
Griffin's Reagent
Acidic Ferric Chloride

Copper and Nickel Alloy
10% or 25% Nitric Acid
10% or 25% Hydrochloric Acid

Brass Alloys
10% or 25% Nitric Acid
Acidic Ferric Chloride

- **Interpretation**
  - Interpretation of results would include full restoration, partial restoration, or unsuccessful restoration. A full restoration would be a total recognition of all obliterated characters. A partial restoration would be recognition of all obliterated characters less than the total being sought. An unsuccessful restoration would be no recognition of any obliterated characters. Notes should include if the restoration procedure was full, partial, or unsuccessful.

- **Literature / Supporting Documentation**

  - Treptow, Richard, S., Handbook of Methods for the Restoration of Obliterated Serial Numbers, NASA, 1978.
  - Polk, Donald, E. and Giessen, Bill, C. "Metallurgical Aspects of Serial Number Recovery", AFTE Journal ,Vol. 21, No. 2, p.174.

- Bureau of Alcohol, Tobacco and Firearms Laboratory, Serial Number Restoration Handbook, 1999.
- Wagoner, Andy. "Griffin's Reagent for Serial Number Restoration in Stainless Steel". <u>AFTE Journal</u>. Vol. 31, No. 4. p 497.

7.3 Electrochemical Restoration

- **Scope**
  - Many valuable items manufactured today have serial numbers for identification. These numbers are usually die stamped. This process produces a compression of the metal or plastic in the area immediately surrounding and a short distance below the penetration of the die. Serial numbers are removed and/or obliterated in a variety of ways. The serial number may be restored if the removal/obliteration is not taken past the previously mentioned compression zone. The electrochemical technique using the standard chemical etchants is an enhanced form of chemical restoration, in which the application of a voltage potential assists the oxidation of the specimen. The die stamping process is a form of "cold-working" metal. A side effect of cold-working is the decrease of that item's ability to resist chemical attack. Therefore, the utilization of this method will affect the compressed area of the obliterated number faster and to a greater degree than the non cold-worked area surrounding it. This procedure, in conjunction with the polishing procedure, is an effective way to restore an obliterated serial number in magnetic metal.

- **Related Documents**
  - Polishing
  - Magnetic
  - Heat
  - Chemical Restoration

- **Equipment / Materials / Reagents**
  - Power Source
  - Etchants

- **Standards, Controls, and Calibration**
  - **The Standards & Controls for serial number chemical/electro-chemical restoration methods consists of spot testing each reagent to establish efficacy on the item surface or a known metal standard prior to each use. The reagents should create a visible reaction (bubbling, change of color, etc.) on the metallic surfaces if they are working properly. Discard any reagent that fails to react properly and immediately rinse off reagents that appear to over-react.**

- Attach the specimen to the positive terminal of the power supply via an alligator clip.
- Thoroughly soak the cotton tip of an applicator with the appropriate chemical enchant and attach this to the negative terminal of the power supply via an alligator clip, being certain to do so on a moistened area at the base of the cotton tip.
- Turn on the power supply and adjust the voltage to 6V.
- Spot test the reagent in a discrete area away from the obliteration. Immediately rinse off any reagent that appears to over-react. Document the results.
- Wipe the area of obliteration, being careful to not touch the surface of the specimen with the alligator clip.
- Note any characters that become visible prior to proceeding with each step, as well as during the wiping process.
- If any characters do not become visible, proceed to the appropriate chemical restoration procedure.

- **Interpretation**
  - Interpretation of results would include full restoration, partial restoration, or unsuccessful restoration. A full restoration would be a total recognition of all obliterated characters.
  - A partial restoration would be recognition of all obliterated characters less than the total being sought. An unsuccessful restoration would be no recognition of any obliterated characters. Notes should include if the restoration procedure was full, partial, or unsuccessful.

- **Literature / Supporting Documentation**

  - Treptow, Richard, S., Handbook of Methods for the Restoration of Obliterated Serial Numbers, NASA, 1978.
  - Polk, Donald, E. and Giessen, Bill, C. “Metallurgical Aspects of Serial Number Recovery”, AFTE Journal, Vol. 21, No. 2, p.174.
  - Bureau of Alcohol, Tobacco and Firearms Laboratory, Serial Number Restoration Handbook, 1999.
  - Turley, Dennis M. Restoration of Stamp Marks on Steel Components by Etching and Magnetic Techniques. JFS 32(3): 640-649.
  - Deats, Marcellus. Serial Number Restoration Information. AFTE Journal 12(3): 82-83.
  - Matthews, J. Howard. Firearms Identification. Volume I. pp 77-80. Charles C. Thomas. Springfield, Illinois. 1962.
  - Miller, Ken E., Current Assist for Die Stamp Impression Restoration, AFTE Journal 4(3): 38.

7.4 Magnetic Restoration

- **Scope**
  - Many valuable items manufactured today have serial numbers for identification. These numbers are usually die stamped. This process produces a compression of the metal or plastic in the area immediately surrounding and a short distance below the penetration of the die. Serial numbers are removed and/or obliterated in a variety of ways. The serial number may be restored if the removal/obliteration is not taken past the previously mentioned compression zone. The Magnaflux® technique is used by metallurgists to detect surface or subsurface flaws in iron or steel. Magnetic particles, applied to a magnetized specimen, outline the obliterated characters in a successful restoration. A side effect of cold working is the increase of that item's magnetism. Therefore, the utilization of this method will affect the compressed area of the obliterated number rather than the non cold-worked area surrounding it. This procedure, in conjunction with the polishing procedure, is an effective way to restore an obliterated serial number in non-magnetic metal. The Magnaflux® technique is nondestructive, and can be applied without hindering other restoration methods.

- **Safety**

NFPA Listings				
Chemical	**Health Hazard**	**Flammability Hazard**	**Reactivity Hazard**	**Contact Hazard**
9CM Prepared Bath	1	4	0	
7HF Prepared Bath	1	4	0	
14AM Prepared Bath	1	4	0	

  - **WARNING!** 9Cm Prepared Bath is highly flammable and can pose a **SEVERE SAFETY HAZARD.**
  - **WARNING!** 7 HF Prepared Bath is highly flammable and can pose a **SEVERE SAFETY HAZARD.**
  - **WARNING!** 14 AM Prepared Bath is highly flammable and can pose a **SEVERE SAFETY HAZARD.**
  - **WARNING!** SKC-S Cleaner Remover is highly flammable and can pose a **SEVERE SAFETY HAZARD.**

- **Storage Requirements**
  - Chemicals will be stored in the Firearm/Toolmark Lab's designated cabinet or flammable storage container.

- Chemical storage is located in the workshop area of the laboratory.

- **Related Documents**
  - Polishing
  - Electrochemical Restoration
  - Heat Restoration
  - Chemical Restoration
- **Equipment / Materials / Reagents**
  - UV light source (if 14AM Prepared Bath is being used).
  - Yoke magnets
  - Y-7 AC/DC Yoke electromagnet

- **Standards, Controls, and Calibration**
  - none

- **Procedure**
  - Ascertain whether the specimen is suitable for testing with Magnaflux® by placing a magnet on the area of obliteration. The specimen is suitable if it can be magnetized.
  - Clean the area of obliteration with the SKC-S Cleaner/Remover by spraying this onto the surface and wiping. Allow this to dry before proceeding.
  - Apply Prepared Bath to the area of obliteration with a disposable pipette.
  - Place the magnet behind the area of obliteration, with the poles on either side of the area. This placement may be adjusted to reveal more or different areas of the obliteration.
  - If 14AM (Fluorescent) Prepared Bath is being used, observe the characters under a black light.
  - Note any characters that become visible prior to proceeding with each step.
  - If any characters do not become visible, proceed to the appropriate chemical restoration procedure.

- **Interpretation**
  - Interpretation of results would include full restoration, partial restoration, or unsuccessful restoration. A full restoration would be a total recognition of all obliterated characters. A partial restoration would be recognition of all obliterated characters less than the total being sought. An unsuccessful restoration would be no recognition of any obliterated characters. Notes should include if the restoration procedure was full, partial, or unsuccessful.

- **Literature / Supporting Documentation**
  - Treptow, Richard, S., Handbook of Methods for the Restoration of Obliterated Serial Numbers, NASA, 1978.
  - Polk, Donald, E. and Giessen, Bill, C. "Metallurgical Aspects of Serial Number Recovery", AFTE Journal, Vol. 21, No. 2, p.174.
  - Bureau of Alcohol, Tobacco and Firearms Laboratory, Serial Number Restoration Handbook, 1999.
  - O'Reilly, W.E. Magnetic Restoration of Serial Number. AFTE Journal 7: 26-27.
  - Schaefer, Jeffrey. Serial Number Restoration Observations. AFTE Journal 19(3): 276-278.
  - Turley, Dennis M. Restoration of Stamp Marks on Steel Components by Etching and Magnetic Techniques. JFS 32(3): 640-649.

7.5 Heat Restoration

- **Scope**
  - Many valuable items manufactured today have serial numbers for identification. These numbers are usually die stamped. This process produces a compression of the metal or plastic in the area immediately surrounding and a short distance below the penetration of the die. Serial numbers are removed and/or obliterated in a variety of ways. The serial number may be restored if the removal/obliteration is not taken past the previously mentioned compression zone. The Heat procedure is suitable for restoration of serial numbers in plastic. The die stamping or embossing process is a form of "cold-working" plastic. A side effect of cold working is the decrease of that item's ability to resist heat. Therefore the utilization of this procedure will affect the compressed area of the obliterated number faster and to a greater degree than the non cold-worked area surrounding it. This procedure, in conjunction with the polishing procedure, is an effective way to restore an obliterated serial number in heat.

- **Related Documents**
  - Polishing

- **Equipment / Materials / Reagents**
  - High Intensity Lamp

- **Standards, Controls, and Calibration**
  - none

- **Procedure**
  - Apply heat to the area of obliteration utilizing a high intensity lamp.

- Continue the application of heat until the plastic in the obliterated area starts to liquefy.
- If any characters become visible, note these characters.

- **Interpretation**
  - Interpretation of results would include full restoration, partial restoration, or unsuccessful restoration. A full restoration would be a total recognition of all obliterated characters. A partial restoration would be recognition of all obliterated characters less than the total being sought. An unsuccessful restoration would be no recognition of any obliterated characters. Notes should include if the restoration procedure was full, partial, or unsuccessful.

- **Literature / Supporting Documentation**
  - Treptow, Richard, S., Handbook of Methods for the Restoration of Obliterated Serial Numbers, NASA, 1978.
  - Polk, Donald, E. and Giessen, Bill, C. "Metallurgical Aspects of Serial Number Recovery", AFTE Journal, Vol. 21, No. 2, p.174.
  - Bureau of Alcohol, Tobacco and Firearms Laboratory, Serial Number Restoration Handbook, 1999.
  - Roberts, Van, "Restoration of Serial Numbers in Plastic", AFTE Journal. Vol. 13, No. 4, p. 40.

8 FRACTURE MATCH EXAMINATION

8.1 Introduction

Fracture matching is the process of matching two or more objects either through physical, optical, microscopic, or photographic means, permitting an examiner to conclude whether the objects were one entity that was broken, torn, separated, or held or bonded together in a unique arrangement, The examination maydetermine whether or not two or more objects were at one time joined and were a part of the same unit. Other related procedures include casting and microscopic comparison.

8.2 Safety Considerations

Refer to the Lab Safety Manual and use personal protective equipment to avoid exposure to potentially hazardous material.

8.3 Instrumentation

- Stereo microscope
- Comparison microscope
- Photographic equipment

- Casting materials
- Other equipment as needed

8.4 Minimum Analytical Standards and Controls

Confirm that the equipment utilized in the examination has been appropriately calibrated by a qualified vendor and/or performance checked prior to use.

8.5 Procedure or Analysis

- A systematic approach should be used for the fracture match examination, with recording of findings and observations in the notes by documenting and/or photographing the separated items.

- Initial visual inspection of the items submitted would include evidence of:
  - Surface condition
  - Method of separation
  - Physical composition
  - Color / Coating
  - General dimensions of the items
  - Pattern
  - Appearance and/or distortions of the separated edges
  - Cross-sectional contours
  - Incidental striations or scratches
  - Extrusion markings
  - Type of fracture
  - Trace material
- Microscopically examine the items to determine if they contain marks suitable for microscopic comparison.
- Visually examine the items to determine if they can be physically oriented to one another.
- Microscopically examine the oriented edges using a stereo microscope and/or comparison microscope, as appropriate, looking for the presence of corresponding irregularities in the oriented edges.
- Based on the microscopic evaluation of the objects, determine whether sufficient microscopic correspondence exists between the objects to identify them as having been joined at one time, as one entity.
- A cast of one of the separated edges can be made for comparison with the other separated edge using a comparison microscope. If a cast is made it shall be designated as a sub-item of the evidence from which it is derived, listed in LIMS with appropriate chain of custody documented.

- Casts shall be submitted to the ECU (Evidence Control Unit) in an appropriate sealed container, in the same container with the item it was generated from. Case notes shall indicate the container information in which casts are being returned.

8.6 Interpretation of Results

- Oriented index marks (e.g., blue ink index mark at 6 o'clock) on compared items shall be used for comparison, conclusion documentation.
- Digital images that are produced of the comparisons shall describe the specific item / test numbers for each specimen depicted, with the magnification and the index orientation.

Comparison Conclusions

Identification
Criteria: Agreement of a combination of individual characteristics and all discernible class characteristics where the extent of agreement exceeds that which can occur in the comparison of toolmarks made by different tools and is consistent with the agreement demonstrated by toolmarks known to have been produced by the same tool.

Documentation: Digital images shall be made of the areas / marks that are used by the examiner to reach the opinion identification.

Inconclusive
Criteria: (1) Some agreement of individual characteristics and all discernible class characteristics, but insufficient for an identification. (2) Agreement of all discernible class characteristics without agreement or disagreement of individual characteristics due to an absence or insufficiency of detail or lack of reproducibility. (3) Agreement of all discernible class characteristics and disagreement of individual characteristics, but insufficient for an elimination.

Documentation: When an item will be reported as insufficient for identification or elimination (inconclusive), fractured edges or marks that are present shall be digitally photographed, and documentation for the reason(s) why the marks are insufficient.

Elimination
Criteria: Significant disagreement of discernible class characteristics and/or individual characteristics.

Documentation: When an item will be reported as an elimination, differences in the fractured edges or marks that are present shall be digitally photographed, and documentation for the reason why the marks support the conclusion of elimination.

8.7 References

- Association of Firearm and Tool Mark Examiners Procedures Manual, 2001. Glossary of the Association of Firearms and Tool Mark Examiners, 5th ed., 2007.
- Saferstein, R. Ed. Forensic Science Handbook. Chapter 4. “Forensic Glass Comparisons”. p. 151-153. Prentice- Hall, Inc. New York. 1982.
- Thornton, John I. “Fractal Surfaces as Models of Physical Matches”. Journal of Forensic Sciences. Vol. 31, No. 4, Oct. 1986. p. 1435-1438.
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