Technical Procedure for Fired Projectile Examination

Purpose – To outline the procedures for examination and comparison of fired projectile evidence.

Scope – This procedure applies to cases submitted to the Firearms Section that contain fired projectiles.

Definitions

- **Air gap** – The distance between the measuring surfaces (the face of the anvil and the face of the spindle) of a micrometer.
- **Anvil** – The part of a micrometer bearing the fixed measuring surface.
- **Axial engraving** – Reproducible striations on a bullet which occur during firing and before engagement with the rifling. These are caused by the misalignment of the bullet with the axis of the bore.
- **Bearing surface –** The portion of a bullet's outer surface that comes into direct contact with the interior surface of the barrel.
- **Caliber (Ammunition)** – A numerical term, without the decimal point, included in a cartridge name to indicate the nominal bullet diameter.
- **Cannelure** – A circumferential groove generally of a knurled or plain appearance on a bullet or cartridge case that is typically used for crimping, lubrication, and identification.
- **Class characteristics** – Measurable features of a specimen which indicate a restricted group source. They result from design factors, and are therefore determined prior to manufacture.
- **Comparison microscope** – Essentially two microscopes connected to an optical bridge which allows the viewer to observe two objects simultaneously with the same degree of magnification.
- **Gauge** – A term used in the identification of a shotgun bore. The number of round lead balls of bore diameter that equal one pound. Thus 12 gauge is the diameter of a round lead ball weighing 1/12 pound.
- **Grain** – A unit of weight. 7000 grains equal one pound. The grain unit is commonly used in American and English ammunition practice to measure the weight of components.
- **Groove impression –** The impression on the bearing surface of a fired bullet created by the groove of a rifled barrel.
- **Individual characteristics** – Marks produced by the random imperfections or irregularities of tool surfaces. These random imperfections or irregularities are produced incidental to manufacture and/or caused by use, corrosion, or damage. They are unique to that tool and distinguish it from all other tools.
- **Land impression** – The impression on the bearing surface of a fired bullet created by the land of a rifled barrel.
- **Nominal caliber** – The caliber family to which a particular ammunition component belongs (e.g., .22, .30, .32, .38, 9mm, .45, etc.).
- **Oblique lighting** – A method of illumination where the light source is placed at an angle, generally to produce shadows or enhance edges.
- **Pellet** – A common name for the small spherical projectiles loaded in shotshells. Also known as shot. May also refer to a nonspherical projectile used in some air rifles and air pistols.
- **Projectile** – An object propelled by the force of rapidly burning gases or other means.
- **Shave mark** – A mark caused by the cutting of metal from a bullet due to cylinder misalignment in a revolver.
- **Shot** – Spherical pellets used in loading shotshells or cartridges.
- **Skid mark** – Rifling mark formed on the bearing surface of bullets as they enter the rifling of the barrel before rotation of the bullet starts. Skid marks are typically produced by revolvers and have the appearance of widening the land impressions at their beginning point.
- **Slippage** – The widening of land impressions seen when a bullet slips across the land of a rifled barrel; may widen the land impression along its length and at the base.

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- **Slug** – A term applied to a single projectile for shotshells.
- **Spindle** – The part of a micrometer bearing the moveable measuring surface.
- **Stereomicroscope** – An optical instrument which provides three dimensional viewing of an object through paired objectives and eyepieces. Some models share a common main objective.
- **Subclass characteristics –** Features that may be produced during manufacture that are consistent among items fabricated by the same tool in the same approximate state of wear. These features are not determined prior to manufacture and are more restrictive than class characteristics.
- **Sufficient agreement** – Agreement is sufficient when it exceeds the best agreement demonstrated between tool marks known to have been produced by different tools and is consistent with the agreement demonstrated by tool marks known to have been produced by the same tool.

Equipment, Materials, and Reagents

- Comparison microscope
- Stereomicroscope
- Balance
- Caliper
- Micrometer
- Engraver
- Magnet
- Leica Application Software (LAS)
- AFTE Glossary
- FBI General Rifling Characteristics File
- Ammunition Reference Collection
- Cotton-tipped swabs
- Cleaning solutions such as Terg-A-Zyme, Hibiclens, ethanol, and acetone
- Personal protective equipment
- Soft bristle brush

Procedure

5.1 Fired Projectile Examination

5.1.1 Item Preparation

5.1.1.1 Prior to analysis, ensure that any additional examinations (e.g., Forensic Biology, Trace, Latent, etc.) that must be completed before analysis by the Firearms Section have been completed.

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

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

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5.1.1.3 Projectiles that are contaminated with a potentially bio-hazardous material may be cleaned with a soft bristle brush and a disinfectant such as Terg-A-Zyme, Hibiclens, and/or ethanol.

5.1.1.4 Projectiles may generally be cleaned with a cotton-tipped swab saturated with ethanol or acetone.

5.1.1.5 If a portion of a jacket obscures the bearing surface, it may be carefully unfolded as needed to expose any underlying individual characteristics. Sharp or pointed surfaces (especially "talons") of metal jackets or jacket fragments may be crimped or repositioned so as to minimize the potential for injury during handling.

5.1.1.6 Mark all evidence bullets/projectiles for identification.

5.1.2 Physical Characteristics Examination

5.1.2.1 A separate worksheet shall be made for each evidence bullet. Similar information as applicable for slugs, pellets, and wads shall be recorded on a Shotshell Worksheet.

5.1.2.2 Features of fired projectiles that shall be noted, if applicable, include:

5.1.2.2.1 Design characteristics of the fired projectile:

- Caliber/gauge (see 5.1.3)
- Weight, measured in grains
- Composition
- Type/design
- Damage or deformation

5.1.2.2.2 Class characteristics of the firearms that fired the projectile:

- Number of land and groove impressions physically present (see 5.1.4.1 for calculating total number)
- Type of rifling (conventional or polygonal)
- Direction of twist of the land and groove impressions

5.1.2.3 Features of fired projectile that may be noted, if applicable, include:

5.1.2.3.1 Design characteristics of the fired projectile:

- Base design
- Manufacturer/marketer, if possible to determine
- Cannelure type and location
- Presence of gunpowder and/or powder imprints adhering to the base

5.1.2.3.2 Class characteristics of the firearm that fired the projectile:

- Width of land and groove impressions (see 5.1.4.2 for measurement methods)

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- Markings that may indicate a particular type or condition of firearm, including skid marks, slippage marks, shave marks, flared base, etc.
- Striations on a wad that may be suitable for identification to the shotgun that fired it

5.1.2.4 If a fired projectile will be microscopically compared to either another evidence item or to a submitted firearm, the item must first be evaluated to identify characteristics suitable for comparison.

5.1.2.4.1 The result of this evaluation will be recorded in the case notes.

5.1.2.5 If items of different calibers will not be microscopically compared, the following statement will be included in the case notes and report:

5.1.2.5.1 "Items of different calibers were not microscopically compared to one another; there were no indications/observations of improper calibers having been fired by a firearm."

5.1.3 Determination of Caliber or Gauge

5.1.3.1 **Bullets** – the following may be utilized to determine the caliber of any fired bullet. The condition of the bullet shall determine which steps may be used.

5.1.3.1.1 Compare the base diameter of the evidence bullet directly with known standards.

5.1.3.1.2 Measure the base diameter of the evidence bullet using a calibrated measuring device and compare this measurement with known measurements published in reference literature.

5.1.3.1.3 Determine the number and widths of the land and groove impressions and compare to the Land and Groove Impression Width table of the Appendices section of the AFTE Glossary. This table provides nominal caliber only.

Nominal caliber may be calculated using the following formula:

$$\mathbf{d = N(L+G)/\pi}$$

where d = bore diameter
N = total number of lands and grooves
L = width of one land impression
G = width of one groove impression
π = pi = 3.1416

5.1.3.1.3.1 This formula is extrapolated from the formula represented in the AFTE Glossary and in an article from the AFTE Journal titled "Land and Groove Tabulation."

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5.1.3.1.3.2 If this formula is used to determine nominal caliber, the AFTE Journal article shall be imported into the case file.

5.1.3.1.4 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.

5.1.3.2 **Cores** – the following may be utilized to determine the minimum nominal caliber of a bullet core. The minimum nominal caliber of core shall be determined if requested by the submitting agency or at the discretion of the Forensic Scientist. The condition of the core shall determine which steps may be used.

5.1.3.2.1 Measure the base diameter of the evidence core using a calibrated measuring device and compare this measurement with known measurements published in reference literature.

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

5.1.3.2.3 The weight, diameter, and/or design of a bullet core can be used to deduce the **minimum** nominal caliber.

5.1.3.2.3.1 When the minimum caliber has been determined, the item description for a core shall include the minimum caliber and the phrase "or larger" (eg. "caliber 38 Class or larger").

5.1.3.3 **Slugs** – the following may be utilized to determine the gauge of a fired slug. The condition of the slug shall determine which steps may be used.

5.1.3.3.1 Compare the base diameter of the evidence slug directly with known standards.

5.1.3.3.2 Measure the base diameter of the evidence slug using a calibrated measuring device and compare this measurement to known measurements published in reference literature, including the Rifle Slug Characteristics table of the Appendices section of the AFTE Glossary.

5.1.3.3.3 Weigh the evidence slug in grains and compare to known weight published in reference literature, including the Rifled Slug Characteristics table of the Appendices section of the AFTE Glossary.

5.1.3.4 **Shot** – determine the total number of pellets received, the composition of the pellets, and the number of pellets suitable for comparison purposes. Note if pellets all appear to be similar in size. If several different sizes are present, determine each individual size. The Forensic Scientist may use one or all of the following techniques to determine shot size.

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5.1.3.4.1 Visual/Microscopic Comparison

Compare Laboratory standards of known shot sizes side by side with the evidence pellets until a known shot size is determined. A stereomicroscope may aid in this determination. This may be done one size at a time or several sizes at a time; however, if more than one size is used at a time, care shall be taken not to mix up the shot.

5.1.3.4.2 Comparison by Weight

5.1.3.4.2.1 Weigh the pellets in grains.

5.1.3.4.2.2 Divide weight of pellets by total number weighed.

5.1.3.4.2.3 Consult known pellet weights in the Shot Sizes and Weights and the Lead Buck Shot Information tables of the Appendices section of the AFTE Glossary.

5.1.3.4.2.4 The weight of the evidence pellets may also be directly compared to the weight of standard shot using the same number of pellets until a similar known weight is obtained.

5.1.3.4.3 Measuring Pellet Size

5.1.3.4.3.1 Choose the most intact or un-deformed specimen and measure the diameter using a calibrated measuring device.

5.1.3.4.3.2 Consult known shot sizes in the Shot Sizes and Weights and the Lead Buck Shot Information tables of the Appendices Section of the AFTE Glossary.

5.1.3.5 Wads – the following may be utilized to determine the gauge of a fired wad. The condition of the wad shall determine which steps may be used.

5.1.3.5.1 Directly compare the evidence wad to known Laboratory standards of similar manufacture or composition by comparing the base of the evidence to the bases of the standards until a similar known size is obtained.

5.1.3.5.2 Measure the base diameter of the wad and compare these measurements to known measurements.

5.1.3.5.3 Manufacturer data may be determined by locating information stamped into the wad or by comparing the evidence wad to known Laboratory references.

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5.1.4 Rifling Characteristics

5.1.4.1 For damaged bullets for which the total number of land and groove impressions cannot be visually determined, this number shall be calculated using the following formula:

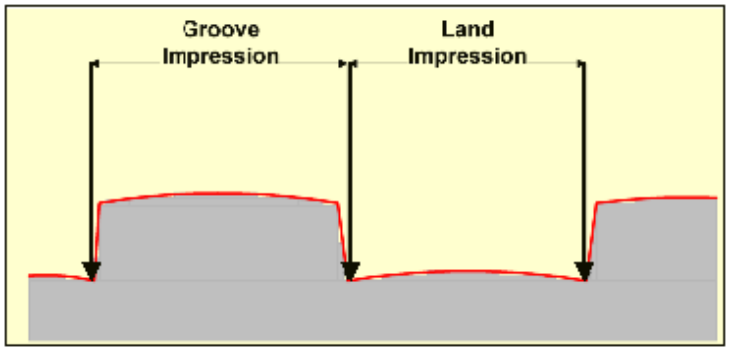
$$N = d\pi/(L+G)$$

where N = total number of lands and grooves
d = bore diameter
π = pi = 3.1416
L = width of one land impression
G = width of one groove impression

5.1.4.1.1 This formula is represented in the AFTE Glossary and in an article from the AFTE Journal titled "Land and Groove Tabulation".

5.1.4.1.2 The value for the bore diameter (d) shall be used from the AFTE article titled "Land and Groove Tabulation".

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



When measuring land and groove impression widths, all suitable land and groove impressions shall be measured and their average measurement, recorded to the nearest thousandth of an inch, shall be recorded in the notes for each bullet. Methods may include the Leica Application Suite Measurement Module and the air gap method.

5.1.4.2.1 **Leica Application Software** - A comparison microscope equipped with the Leica Application Suite (LAS) Measurement Module may be used to make measurements.

5.1.4.2.2 **Air Gap Method**

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5.1.4.2.2.1 The fired bullet is mounted on one stage of the comparison microscope. The measuring device, typically a micrometer, is mounted on the other stage.

5.1.4.2.2.2 Both stages shall use the same magnification level (objective setting) and be in focus.

5.1.4.2.2.3 Align the image of the land or groove impression with one of the anchor points corresponding with the anvil of the micrometer. Rotate the micrometer's spindle to the next anchor point of the land or groove impression and record the measurement gap (opening) of the micrometer to the nearest thousandth of an inch.

5.2 General Rifling Characteristics (GRC) File Protocol

5.2.1 At the request of the submitting agency if an evidence bullet is not identified to a particular firearm, a list of manufacturers of firearms of similar caliber and/or rifling class characteristics shall be compiled using the computerized General Rifling Characteristics File provided by the FBI.

5.2.2 A single list generated using combined class characteristics of both fired bullets and cartridge cases shall not be produced.

5.2.3 A performance check of the FBI GRC Software shall be performed before use (see Attachment A). This performance check shall be recorded in the Completed Tasks area of the worksheet.

5.2.4 Fill in the applicable fields at the bottom of the GRC Search page with the pertinent case information and the information obtained during the examination of the bullet, and run the computerized search of the database files.

5.2.4.1 The search parameters for land and groove impression widths shall include a tolerance of +/- 0.003 inch. This tolerance may be increased due to damage, deformity, poor rifling, etc. at the discretion of the Forensic Scientist in accordance with accepted industry and forensic laboratory standards and based on the analyst's training and experience.

5.2.4.2 Based on the Forensic Scientist's training and experience, the list may be filtered based on characteristics of the bullet that may indicate or exclude a particular caliber or type of firearm.

5.2.4.3 If multiple evidence bullets have been identified to each other, one list of possible firearm manufacturers shall be compiled. The land and groove impression measurements for each bullet shall be incorporated in the search parameters. For example, if two bullets have land impression widths of 0.057 and 0.058 inch with a tolerance of +/- 0.003 inch, the minimum and maximum land impression width search parameters should be 0.054 and 0.061 inch, respectively.

5.2.5 Record this information in the case notes and import the search results generated by the General Rifling Characteristics File into the case file.

5.2.6 Report the list of possible manufacturers in the main body of the Report.

5.2.6.1 Always include a disclaimer notifying the submitting agency that the list may not be all inclusive and should not be used to eliminate any suspect firearm.

5.2.7 If the list consists of more than twenty (20) possible firearm manufacturers, the complete list shall be imported into the Case Record Object Repository and the report shall contain a statement that the list of firearms that may have fired the evidence bullet(s) was too numerous to be of investigative value.

5.3 Class Characteristics Comparison

5.3.1 Should a microscopic comparison be requested, the evidence fired projectiles will first be evaluated for agreement of class characteristics to each other or to a submitted firearm. The Forensic Scientist may ascertain at this point if the class characteristics agree by noting whether or not the direction of twist is the same and whether the number of and widths of land and groove impressions, etc. are similar.

5.3.1.1 If the class characteristics are different and this difference is not attributed to deformity or damage to the firearm after the firing of the evidence projectile, the Forensic Scientist may conclude that the evidence projectile was not fired by the evidence firearm or that the evidence projectiles were not fired by the same firearm.

5.4 Individual Characteristics Comparison

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

5.4.1.1 Select the correct objective (magnification) setting and ensure that the objectives are locked in place. Low magnification (10X - 15X) is typically used to examine the entire bearing surface looking for areas with the most obvious individual characteristics. Higher magnification (20X or greater) is typically used to verify the correspondence of finer striations.

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

5.4.1.3 Mount a bullet on each stage of the comparison microscope with the noses facing to the left. If the comparison is performed with the noses toward the right, the notes shall reflect this orientation.

5.4.1.4 If a firearm was submitted for comparison, compare the test bullets fired by this firearm to each other to determine which microscopic characteristics are reproducing. If the test bullets cannot be matched to each other (the agreement is not sufficient), more test bullets may be fired and inter-compared. If the test fired bullets still cannot be matched, the Forensic Scientist may reach the conclusion that the firearm barrel in question does not reproduce its individual characteristics very

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well or that the firearm barrel does not produce sufficient individual marks to reach a positive conclusion.

5.4.1.4.1 If the test bullets can be matched to each other, the area of best agreement or the area with the most obvious striae shall be indexed with an indelible marker.

5.4.1.5 Compare evidence fired bullet(s) to either another evidence fired bullet or a test fired bullet.

5.4.1.5.1 In the case of comparison to a test fired bullet, attempt to locate the area on the evidence bullet that corresponds to the previously indexed area of the test bullet.

5.4.1.5.2 When comparing evidence bullets to each other, an area with obvious individual characteristics may be noted on one bullet. The other bullet may then be examined in an attempt to locate the corresponding area.

5.4.1.5.3 When and if this area is found, align the edges of the corresponding land or groove impression. These examinations shall be made with the bullets in phase. This means that the edges of the land or groove impressions of both bullets align with each other and the relationship of the other land and groove impressions visible in the viewing area is the same.

5.4.1.5.4 The entire unknown shall be considered. Rotate both bullets simultaneously, examining and comparing each land impression and each groove impression from base to nose until the Forensic Scientist concludes there is sufficient agreement to match or there is not sufficient agreement to match.

5.4.1.5.5 Evaluate for subclass characteristics.

5.4.1.5.5.1 If subclass characteristics are present on either the evidence projectile(s) or the test fired projectiles but not present on both and is not attributed to deformity or damage to the firearm after the firing of the evidence projectile, the Forensic Scientist may conclude that the evidence projectile was not fired by the evidence firearm or that the evidence projectiles were not fired by the same firearm.

5.4.1.5.5.2 Subclass characteristics can be used for alignment and phasing of evidence and/or test fired projectiles.

5.4.1.5.5.3 The method and outcome of evaluation shall be noted in the Comparison Exams worksheet.

5.4.1.5.6 If the bullets can be matched to each other, the area of best agreement or the area with the most obvious striae shall be indexed with an indelible marker.

5.4.1.5.6.1 The evidence bullet may be damaged or deformed in the area of the index. It may be necessary to use other areas of the indexed bullet to compare to the undamaged areas of the evidence bullet.

5.4.1.5.6.2 If the evidence bullet is missing the indexed area or if it is just a portion of a bullet, the evidence shall be indexed at the best area on the evidence bullet with a different color index mark. The previously indexed bullet(s) shall then be indexed again at this area of agreement with the same color index mark (different color than already present).

5.4.1.5.7 <u>If an identification is not initially made, the Forensic Scientist may consider the following possible reasons for the lack of sufficient agreement:</u>

5.4.1.5.7.1 The evidence bullet and test bullets were fired by different firearms.

5.4.1.5.7.2 The firearm was damaged between firing the evidence bullet and the test bullets.

5.4.1.5.7.3 The test ammunition available is significantly different from the evidence causing a difference in the way the bullet is marked.

5.4.1.5.7.4 Misalignment occurs between chamber and barrel causing marks to differ on bullets fired by different chambers.

5.4.1.5.7.5 Extreme leading or corrosion is/was present in the barrel, either prior to firing the evidence bullet or occurring since the evidence bullet was fired.

5.4.1.5.7.6 Damage occurred to the evidence bullet causing distortion, deformation or the elimination of microscopic detail.

5.4.1.5.7.7 The evidence bullet was fired by a firearm of an incorrect caliber.

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

5.4.2 Similar microscopic protocols may be used for the comparison of individual markings found on slugs and wadding material.

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5.5 Range of Conclusions

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

5.5.2 Identification

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

- "The Item 3 bullet was fired by the Item 1 revolver."
- "Items 5 through 7 were fired by the same firearm."
- "The Item 8 and 9 bullets were fired by the same firearm as the Item 1 through 3 bullets."

5.5.3 Inconclusive

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

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

There is agreement of all discernible class characteristics and possible agreement of individual characteristics, but the potential for subclass carryover could not be eliminated; or

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

- "There is agreement of all discernible class characteristics between the Item 3 bullet and test bullets fired by the Item 1 pistol; however, the comparison of individual characteristics was inconclusive. Therefore, Item 3 could not be identified or eliminated as having been fired by Item 1."
- "There is agreement of all discernible class characteristics between the Item 7 and 9 bullets; however, the comparison of individual characteristics was inconclusive. Therefore, Item 7 and 9 could not be identified or eliminated as having been fired by the same firearm."
- "There is agreement of all discernible class characteristics and possible individual characteristics between the Item 7 and 8 fired bullets and test fires created using the Item 5 pistol. However, the potential for subclass carryover could not be eliminated. Therefore, Items 7 and 8 were either fired by Item 5, or by a different firearm(s) manufactured with the same tool in the same approximate state of wear."

5.5.4 Elimination

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

- "Item 17 was not fired by Item 4."
- "The Item 11 and 12 bullets were fired by different firearms."
- "The Item 6 bullet was fired by a different firearm than the Item 7 through 15 bullets."

5.5.5 Not Microscopically Compared

5.5.5.1 The fired evidence in question is not suitable for comparison purposes (e.g. no marks of value, limited quantity of detail of unknown origin).

- "Item 12 is unsuitable for comparison purposes."

5.5.5.2 Projectiles are different calibers than each other or a submitted firearm.

- "Items of different calibers were not microscopically compared to one another; there were no indications/observations of improper calibers having been fired by a firearm ."

5.5.5 Forensic Scientists shall include in their notes all conclusions reached from the microscopic comparison of evidence bullets and/or test fired ammunition components. Forensic Scientists shall also explain their reasons for reaching these conclusions. The reasons shall be clear and succinct and shall be able to be understood by another competent forensic firearms scientist. The Forensic Scientist shall include the position and type of index marks used and which of the test fires (if an evidence firearm was fired) was used or if more than one test fire was used to reach the conclusions.

5.6 Standards and Controls – N/A

5.7 Calibration – For comparison microscope, balance, caliper, and micrometer calibration information, see the Firearms Section Technical Procedure for Instrument Calibration and Maintenance.

5.8 Maintenance – For comparison microscope, stereomicroscope, balance, caliper, and micrometer maintenance information, see the Firearms Section Technical Procedure for Instrument Calibration and Maintenance.

5.9 Sampling – N/A

5.10 Calculations

- For calculating the total number of lands and grooves, see 5.1.4.1.
- For calculating the nominal caliber, see 5.1.3.1.3.

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5.11 Uncertainty of Measurement – The uncertainty of measurement was calculated for projectile weight, projectile diameter, and land and groove impression width measurements.

5.11.1 For projectile weight, the uncertainty of measurement is provided for the balance method, with a coverage factor of k=2 and a coverage probability of 95.45%.

5.11.1.1 The uncertainty of measurement for the balance method is 0.16 grains.

5.11.2 For projectile diameter, the uncertainty of measurement is provided for the caliper method, with a coverage factor of k=2 and a coverage probability of 95.45%.

5.11.2.1 The uncertainty of measurement for the caliper method is 0.015 inches.

5.11.3 For land and groove impression widths, the uncertainty of measurement is provided for the Leica Application Software (LAS) method and the Air Gap method, with a coverage factor of k=2 and a coverage probability of 95.45%.

5.11.3.1 The uncertainty of measurement for the LAS method is 0.005 inches.

5.11.3.2 The uncertainty of measurement for the Air Gap method is 0.004 inches.

5.11.4 The above uncertainties of measurement shall be evaluated annually and updated or revised as needed. In the event of a 25% turnover of scientists approved to perform these measurements, the uncertainties shall be updated or revised.

6.0 Limitations – N/A

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

8.0 References

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9.0 Records

- FA Worksheets
- GRC File Search Results

10.0 Attachments

- FBI GRC Database Performance Check Form
- Uncertainty Budget, Weight by Balance
- Uncertainty Budget, Length by Caliper
- Uncertainty Budget, Length by LAS
- Uncertainty Budget, Length by Micrometer

Revision History		
Effective Date	Version Number	Reason
06/25/2021	9	**Header** and throughout– corrected to reflect organizational change. Changed "fired from" to "fired by" throughout. **3.0** – added term and definition for subclass characteristics. **5.1.2.1** changed "entry" to "worksheet" and removed "in FA" Updated **5.1.2.2.1** and **5.1.2.2.2** Added new **5.1.2.3, 5.1.2.3.1,** and **5.1.2.3.2** Added new **5.1.2.4** and **5.1.2.5** and related subsections. **5.1.3.1.1 –** removed "fired test" Added new **5.1.3.2** and related subsections. **5.1.3.1.3** – added table name and removed reference to specific table number and glossary edition. **5.1.3.1.3.1** – removed reference to specific table number and glossary edition Added new **5.1.3.2** and subsections. **5.1.3.3.2** – added table name and removed reference to specific table number and glossary edition. **5.1.3.3.3** – added table name and removed reference to specific table number and glossary edition. **5.1.3.4.2.3** – added table name and removed reference to specific table number and glossary edition. **5.1.3.4.3.2** – added table name and removed reference to specific table number and glossary edition. **5.1.4.1.1** – added table name and removed reference to specific table number and glossary edition. **5.1.4.1.2** – removed reference to putting documents in case file, clarified the value to use of d from formula listed above **5.1.4.2** added "identified to a firearm" **5.2.2** – reworded sentence to clarify meaning. **5.2.3** – added second sentence. Added new **5.3** and related subsections. **5.4** – renamed section from "Comparison Microscope Protocol" to "Individual Characteristics Comparison **5.4.1.4** – updated so test fire comparison is not required prior to evidence **5.4.1.5** – changed "unknown" to "evidence" and removed old **5.3.1.5.1** and **5.3.1.5.1.1** subsections. **5.1.4.2** – added "When measuring land and groove widths," Added new **5.4.1.5.5** and subsections on subclass characterisitics **5.5** – added quotation marks around suggested report wording examples; changed "firearm" to specific firearm types throughout when referencing a submitted firearm; and added "fired" to item descriptions where appropriate. **5.5** – Removed item designations Added new **5.5.5** and related subsections, moved unsuitable result statement here.

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		5.5.3.1 – included sub-class result Added uncertainty of measurement information to **5.11**. **10.0** – added uncertainty budgets Added Appendices B through E.

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Attachment A: FBI GRC Database Performance Check Form

4/14/16
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(02-08-12)

Firearms/Toolmarks Unit
GRC Database Performance Check Form

Performance check for updated version of GRC database consists of five searches to ensure database has correct data:

Search #1:

1. Open GRC database
2. Click GRC Search
3. Select ***Firearm Type: PI – Semi-automatic pistol.***
4. Click Begin Search
5. Total Hits: 4535
6. Click Close

Search #2:

1. Select ***Firearm Type: PI, #Land/Groove: 6, and Twist Direction: Right.***
2. Click Begin Search
3. Total Hits: 3068
4. Click Close

Search #3:

1. Select ***Firearm Type: PI, #Land/Groove: 6, Twist Direction: Right, and Type of Rifling: Polygonal.***
2. Click Begin Search
3. Total Hits: 52
4. Click Close

Search #4:

1. Select ***Firearm Type: PI, #Land/Groove: 6, Twist Direction: Right, Type of Rifling: Polygonal, and Firing Pin Shape: Hemispherical.***
2. Click Begin Search
3. Total Hits: 35
4. Click Close

Search #5:

1. Select ***Firearm Type: PI, #Land/Groove: 6, Twist Direction: Right, Type of Rifling: Polygonal, Firing Pin Shape: Hemispherical, and Breech/Boltface Marks: Circular.***
2. Click Begin Search
3. Total Hits: 3
4. Click Close

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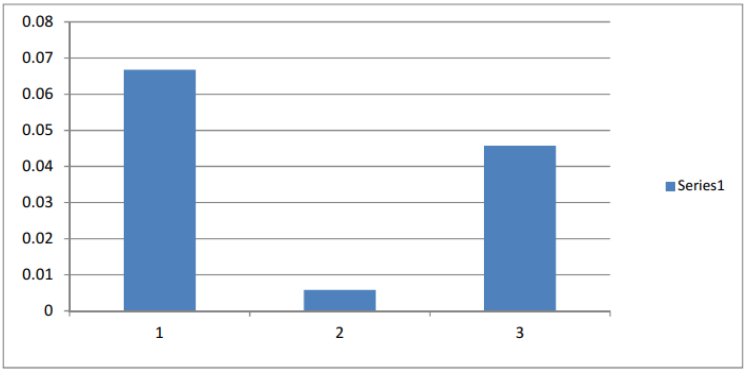
Attachment B: Uncertainty Budget, Weight by Balance

North Carolina State Crime Laboratory
Physical Evidence Section
Firearms Unit
Uncertainty of Measurement Budget
Weight, by Balance

Measurement:	Weight, by Balance
Range of measurement values:	Up to 2314.85 Grains
Procedure name:	Technical Procedure for Fired Projectile Examination
Budget prepared by:	Jessica L. R. Pappas
Date Prepared:	April 4, 2018

Line Item	Uncertainty Component		Value	Units	Distribution	Type	Divisor	Degrees Freedom (n-1)	Standard Uncertainty	Component Contribution %
1	Balance Calibration Uncertainty		0.13360288	grains	normal	B	2.00	∞	0.066801439	56
2	Balance Resolution		0.01000000	grains	rectangular	B	1.73	∞	0.005773503	5
3	Reproducibility Data		0.04571	grains	normal	A	1.00	341	0.04571	39
	Combined Standard Unc	u							0.081149058	100
	Expanded Unc	U (k=2)							0.162298117	
	Reported Uncertainty:		**0.16**		**k=2**	95.45% confidence level				



Notes - document the basis for the data above:

1 Uncertainty of the calibration by CLC Calibration LLC Certificate
$u = \sqrt{(u.eccentricity^2 + u.\ linearity^2 + u.repeatability^2 + u.span^2)}$
$u = \sqrt{(0.00138^2 + 0.0008^2 + 0.00138^2 + 0.00378^2)}$
$u = 0.0043286475$ g
$u.exp\ (k=2) = 0.0086572975$ g = 0.133602878 gr

2 Balance resolution

3 Reproducibility data - average standard deviation of all projectiles measured

The estimation of uncertainty of measurement shall be evaluated annually and updated or revised as needed.

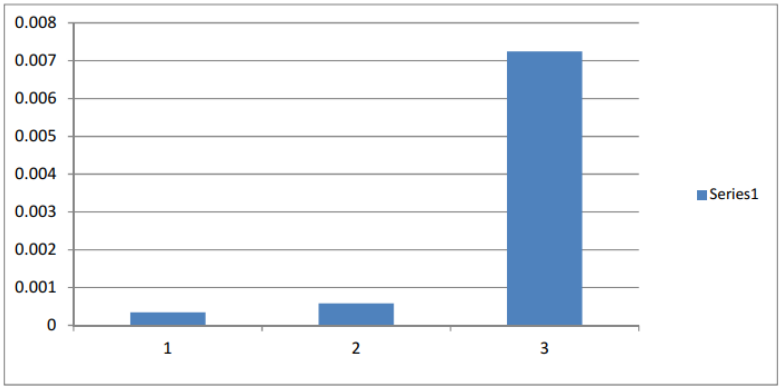
Revision History		
Version Number	**Date**	**Reason**
1	4/4/2018	Original Document

Attachment C: Uncertainty Budget, Length by Caliper

North Carolina State Crime Laboratory
Physical Evidence Section
Firearms Unit
Uncertainty of Measurement Budget
Length, by Caliper

Measurement:	Length, by Caliper
Range of measurement values:	Up to 6 inches
Procedure name:	Technical Procedure for Fired Projectile Examination
Budget prepared by:	Jessica L. R. Pappas
Date Prepared:	April 4, 2018

Line Item	Uncertainty Component		Value	Units	Distribution	Type	Divisor	Degrees Freedom (n-1)	Standard Uncertainty	Component Contribution %
1	Caliper Calibration Uncertainty		0.00069000	inches	normal	B	2.00	∞	0.000345	4
2	Caliper Resolution		0.00100000	inches	rectangular	B	1.73	∞	0.00057735	7
3	Reproducibility Data		0.00724	inches	normal	A	1.00	405	0.00724	89
	Combined Standard Unc	u							0.007274416	100
	Expanded Unc	U (k=2)							0.014548833	
	Reported Uncertainty:		**0.015**		**k=2**	95.45% confidence level				



Notes - document the basis for the data above:

1 Uncertainty of the calibration by J.A. King Certificate = 0.00069 inches at 95.45% level of confidence (k=2)
2 Caliper scale resolution
3 Reproducibility data - average standard deviation of the items measured

The estimation of uncertainty of measurement shall be evaluated annually and updated or revised as needed.

Revision History		
Version Number	**Date**	**Reason**
1	4/4/2018	Original Document

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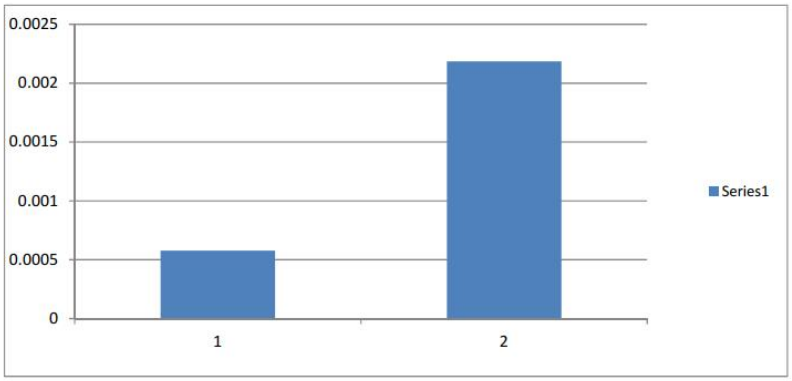
Attachment D: Uncertainty Budget, Length by LAS

North Carolina State Crime Laboratory
Physical Evidence Section
Firearms Unit
Uncertainty of Measurement Budget
Length (L&G widths), by LAS Software

Measurement:	Length (L&G widths), by LAS Software
Range of measurement values:	Up to 0.404 inches
Procedure name:	Technical Procedure for Fired Projectile Examination
Budget prepared by:	Jessica L. R. Pappas
Date Prepared:	April 4, 2018

Line Item	Uncertainty Component		Value	Units	Distribution	Type	Divisor	Degrees Freedom (n-1)	Standard Uncertainty	Component Contribution %
1	LAS Software Resolution		0.00100000	inches	rectangular	B	1.73	∞	0.00057735	21
2	Reproducibility Data		0.00219	inches	normal	A	1.00	279	0.00219	79
	Combined Standard Unc	u							0.002261123	100
	Expanded Unc	U (k=2)							0.004522245	
	Reported Uncertainty:		**0.005**		**k=2**	95.45% confidence level				



Notes - document the basis for the data above:

1 LAS Software scale resolution
2 Reproducibility data - average standard deviation of the five guns measured

The estimation of uncertainty of measurement shall be evaluated annually and updated or revised as needed.

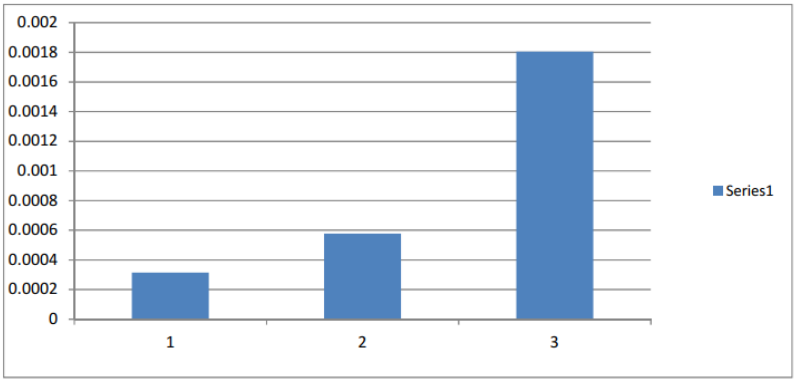
Revision History		
Version Number	**Date**	**Reason**
1	4/4/2018	Original Document

Attachment E: Uncertainty Budget, Length by Micrometer

North Carolina State Crime Laboratory
Physical Evidence Section
Firearms Unit
Uncertainty of Measurement Budget
Length (L&G impression widths), by Micrometer

Measurement:	Length (L&G impression widths), by Micrometer
Range of measurement values:	Up to 1 inch
Procedure name:	Technical Procedure for Fired Projectile Examination
Budget prepared by:	Jessica L. R. Pappas
Date Prepared:	April 4, 2018

Line Item	Uncertainty Component		Value	Units	Distribution	Type	Divisor	Degrees Freedom (n-1)	Standard Uncertainty	Component Contribution %
1	Micrometer Calibration Uncertainty		0.00063000	inches	normal	B	2.00	∞	0.000315	12
2	Micrometer Resolution		0.00100000	inches	rectangular	B	1.73	∞	0.00057735	21
3	Reproducibility Data		0.00181	inches	normal	A	1.00	299	0.00181	67
	Combined Standard Unc	u							0.001921644	100
	Expanded Unc	U (k=2)							0.003843287	
	Reported Uncertainty:		**0.004**		**k=2**	95.45% confidence level				



Notes - document the basis for the data above:

1 Uncertainty of the calibration by J.A. King & Company Certificate = 0.00063 inches at 95.45% level of confidence (k=2)
2 Micrometer scale resolution
3 Reproducibility data - highest standard deviation of the five guns measured

The estimation of uncertainty of measurement shall be evaluated annually and updated or revised as needed.

Revision History		
Version Number	**Date**	**Reason**
1	4/4/2018	Original Document

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