EXAMINATION OF FIRED AMMUNITION COMPONENTS

INTRODUCTION

Firearms identification is a subset of toolmark analysis. Toolmark identification attempts to determine whether a toolmark was produced by a specific tool. Firearms identification is concerned with determining whether a given ammunition component (bullet or cartridge case) was fired from a *particular* gun.

Scientific research to date has shown that no two firearms will produce the same unique marks on projectiles and cartridge cases. These unique marks or individual characteristics are produced by randomly created flaws and imperfections that are produced during the firearm's manufacturing processes as well as due to wear and tear. Based on this principle, a Firearms Examiner can identify ammunition components as having been chambered in, fired from, extracted, and ejected from a particular firearm (see note). The identification is based on a microscopic comparison of the submitted projectile(s) or cartridge case(s) to tests fired in the suspect firearm (see Appendix A).

Barrels of rifles and handguns are manufactured with alternating elevated lands and recessed grooves that are called 'rifling'. The rifled barrel transfers its unique marks to the projectile when the projectile is fired from the firearm. The number, direction and width of these lands and grooves is class specific and will vary from manufacturer to manufacturer. Once the class characteristics of the submitted projectile(s) and the suspect firearm are examined and found to be in agreement, the individual characteristics are then microscopically examined. If the individual characteristics are in agreement, the examiner may conclude that the projectile was fired from a particular firearm (see note).

Cartridge cases come into contact with various parts of the firearm when the cartridge case is fired and/or cycled through the firearm. The cartridge case may possess magazine marks, and/or chamber marks, and/or extractor and ejector marks, and/or firing pin impressions, and/or breechface marks, as well as others. The individual characteristics left by the various firearm components on the surface of the cartridge case allows an Examiner to conduct a microscopic comparison of the marks, and potentially conclude that a cartridge case had been loaded in, chambered in, extracted from, ejected or fired in a particular firearm (see note).

In the cases where a suspect firearm is not recovered, the class characteristics of the projectile(s) and/or cartridge case(s) can be searched according to manufacturer in the General Rifling Characteristics (GRC) database. This database was created by the F.B.I. and provides a list summarizing the possible firearms that may have fired the submitted projectile(s)/cartridge case(s). The GRC search can provide investigative leads and can be used as a screening tool. Although this database is continuously being updated, it has limitations in that it may not include every single firearm, including homemade firearms and some after-market alterations.

EXAMINATION

The laboratory examination may include the following steps:

- Comparison to the ammunition reference collection and literature may help determine the manufacturer of the ammunition

- If a suspect firearm is submitted
  - If class characteristics of both the firearm and the submitted projectile(s)/cartridge case(s) are in agreement, the firearm is test fired
  - Tests are microscopically compared to one another and then compared to the submitted projectile(s)/cartridge case(s) using a comparison microscope
- If no suspect firearm is submitted
  - The class characteristics such as the calibre, as well as the number of land and groove impressions and the direction of twist are noted.
  - The widths of the land and groove impressions of the projectile(s) may be measured.
  - The class characteristics of the cartridge case(s) such as the calibre, the shape of the firing pin impression, the position of the extractor and ejector marks are noted.
  - The class characteristics can be used along with the GRC database and literature to assist in determining the make and model of the firearm
- Submitted projectiles as well as cartridge cases are microscopically compared to determine whether or not they may have been fired from/in the same firearm
- Submitted projectile(s)/cartridge(s) case are submitted to IBIS for upload. See the information sheet for IBIS.

INTERPRETATION

For cases where no suspect firearm was submitted, possible conclusions are

- The calibre of the ammunition component
- A list of possible makes and/or models of firearms that could have fired the submitted projectile(s)/cartridge case(s) is provided
- The firearm from/in which the submitted projectile(s)/cartridge(s) case was/were fired could not be determined

For cases where a suspect firearm was submitted, possible conclusions are

- The submitted projectile(s)/cartridge case(s) was/were identified within the limits of practical certainty, as having been fired from the submitted firearm
- The submitted projectile(s)/cartridge case(s) could neither be identified nor eliminated as having been fired from/in the submitted firearm. This conclusion is drawn when the submitted projectiles(s)/cartridge case(s) and firearm possess the same class characteristics, however, there are insufficient individual characteristics in agreement or disagreement for an identification or elimination
- The submitted projectile(s)/cartridge case(s) was/were not fired from/in the submitted firearm

For cases with submitted projectiles and/or cartridge cases that are microscopically compared to determine whether or not they were fired from/in the same firearm

- The submitted projectiles/cartridge cases were identified within the limits of practical certainty, as having been fired from/in the same firearm(s)
- The submitted projectile(s)/cartridge case(s) could neither be identified nor eliminated as having been fired from/in the same firearm. This conclusion is drawn when the submitted projectiles(s)/cartridge case(s) possess the same class characteristics, however, there are insufficient individual characteristics in agreement or disagreement for an identification or elimination
- The submitted projectiles/cartridge cases were not fired from/in the same firearm

GLOSSARY

Ammunition A cartridge case that contains a projectile that is designed to be fired in a firearm. It is usually comprised of the cartridge case, propellant, primer and projectile. This also includes caseless cartridges and shot shells.

Breechface The part of the breechblock or breech bolt which supports the base of the cartridge case or shotshell during firing.

Cartridge A single unit of ammunition.

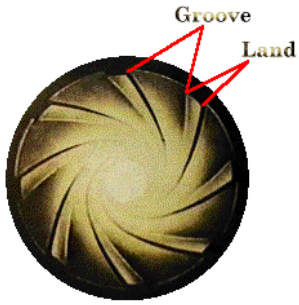
Class characteristics Common feature(s) that is shared by a specific sub-group of the entire population. For example, the number of lands and grooves, the direction of twist, the widths of the lands and grooves, may be specific to one manufacturer but cannot identify an individual firearm.

Comparison microscope Two microscopes connected through an optical bridge, which allows the viewer to observe two objects simultaneously.

GRC file A searchable database created by the F.B.I. that lists various firearms makes and models according to their class characteristics. Certain characteristics may overlap between manufacturers and therefore the search may not yield specific results.

Individual characteristics Imperfections or irregularities that are produced accidentally and randomly during manufacture. They may also be caused by use, abuse, corrosion, rust, or damage to the firearm. The characteristics are unique to that firearm and distinguish it from all other known examples.

Rifling Helical spiral cut grooves in the interior surface (bore) of a firearm barrel that imparts rotary motion to a projectile.



Note: All identification/associations are made within the limits of practical certainty.

Practical Certainty: Since it is not possible to collect and examine samples of all firearms, it is not possible to make an identification with absolute certainty. However all scientific research and testing to date and the continuous inability to disprove the principles of toolmark analysis have demonstrated that firearms produce unique, identifiable characteristics which allow examiners to reliably make identifications.

Firearms/Toolmark Identification: is an empirical science that relies on objective observations and a subjective interpretation of microscopic marks of value.

APPENDIX A – FIREARMS IDENTIFICATION

INTRODUCTION

This appendix provides a summary of the scientific basis for opinion evidence regarding whether or not ammunition components were fired from a particular firearm. Information concerning the validity of the firearms identification discipline, limitations to the analysis/interpretation of firearms evidence and the quality assurance processes utilized at the CFS are also discussed.

EXAMINATION PROCESS

Ammunition components are first assessed based on their **class characteristics.** These are characteristics that indicate a common group source. They are intentional design features chosen by the manufacturer and can include the number, width and direction of land and groove impressions, calibre, shape of firing pin, etc.

Subclass characteristics are discernable surface features that are more restrictive than class characteristics, but not as unique as individual characteristics. Subclass characteristics are produced incidental to manufacture and related to a smaller group source than class characteristics. They are produced within a smaller time frame of manufacturing. Firearms examiners assess the firearms components and/or the features imparted on ammunition components for the potential for subclass carryover.

Once the class characteristics of the ammunition components are examined and found to be in agreement, the **individual characteristics** are then microscopically examined. These marks arise during the manufacturing process and are also a result of use, abuse, corrosion and wear.

Firearm examiners perform their analysis by microscopically comparing the markings on ammunition components. The comparison may be between ammunition components from two unknown sources to determine whether they came from the same firearm, or it may be between ammunition from an unknown source (such as bullets or cartridge cases found at a crime scene) and test-fires from a known source (a recovered firearm).

Cartridge cases come into contact with various parts of the firearm when the cartridge case is fired and/or cycled through the firearm. As a result of this contact, the cartridge case will acquire microscopic marks from different areas(tool) of the firearm.

Barrels of rifles and handguns are manufactured with alternating elevated lands and recessed grooves that are called ‘rifling’. The rifled barrel transfers its marks to the bullet as it passes down the barrel during firing.

Examiners draw their conclusion based on the extent of agreement/disagreement of the markings observed between the two comparison items.

Conclusions include:

Identification - the ammunition components were fired by the questioned/same firearm

Elimination - the ammunition components were not fired by the questioned/same firearm

Inconclusive - the ammunition components can neither be identified nor eliminated as having been fired by the questioned/same firearm

An identification will be declared where there is agreement of class characteristics and sufficient/overall agreement in the individual markings observed on the two items. An elimination will be declared where there is disagreement of class characteristics or when there is an agreement of class characteristics with sufficient/overall disagreement in the individual markings observed on the two items. Finally, an inconclusive is declared when there is agreement of class characteristics with neither sufficient/overall agreement nor disagreement in the individual markings observed on the two items.

LIMITATIONS

- **PRACTICAL CERTAINTY**

Since it is not possible to collect and examine samples of all firearms, it is not possible to make an identification with absolute certainty. However, all scientific research and testing to date and the continuous inability to disprove the principles of toolmark analysis have demonstrated that firearms produce unique, identifiable characteristics which allow examiners to reliably make identifications.

Since it is not possible to examine every firearm that has been manufactured, studies have been conducted on consecutively manufactured firearms/firearm parts. These firearms/firearm parts are manufactured one right after the other, using the same tools. One would expect to see the greatest amount of similarity between these parts since there would have been the least amount of time for change to occur on the tooling surfaces that created them.

The results of these studies have shown that examiners are able to identify the ammunition components back to their respective firearms and establish that consecutively manufactured firearms can be distinguished from one another.

- **THRESHOLDS, RELIABILITY & VALIDITY**

Firearm & toolmark analysis is both an objective and subjective process. Objective observations are made during the microscopic comparison of ammunition components and this is coupled with a subjective interpretation of the significance of those observations. There is no set threshold for deciding whether two samples can be said to come from the same source. It relies fundamentally on human judgment to draw a conclusion and is influenced by an examiner's training and experience. Despite this, research has demonstrated that trained examiners can reliably and repeatably render the same source conclusions.

The validity of the discipline is established through research studies that incorporate elements that evaluate repeatability, reproducibility and accuracy of the method. Research studies can be designed in numerous ways. Recent emphasis has been placed on black box studies as the best method to evaluate the validity and reliability of firearms comparison.

A black box study is a type of study that is used to measure the accuracy and reliability of methods and techniques that rely on human interpretation. In a black box study, all comparisons are independent of each other (one-to-one comparisons), participants have no prior knowledge of the samples and cannot deduce the answers because there is no guarantee that the correct source is present. Test providers also have no prior knowledge of the samples provided and test kits are randomized with providers having no knowledge of who received each kit.

All black box studies measure how often examiners reach accurate conclusions across many feature-comparison problems involving samples representative of the intended use. They empirically measure the overall error rate across many examiners, which can provide an overall impression of the accuracy and reliability of the method itself when error rates cannot be measured or are not available.

There have been numerous studies, including several black box study designs, conducted to test the validity of firearms identification. Results from all study types support the conclusion that firearms examiners are able to reliably render source conclusions.

- **ERROR RATES**

There is no official error rate either for individuals or the firearms discipline because the ground truth is not known in casework. Research, proficiency tests and validation studies can however provide a reliable estimate of potential error; the studies do not establish an error rate. Errors in tests are reflective of individual errors and the failure of that individual's criteria for identification. Conclusions include identification, elimination and inconclusive; however, since inconclusive findings are neither right nor wrong, it is challenging to include inconclusive answers in the error rate calculation. Of the various studies conducted, error rates are typically less than 2%[1]. These rates relate to the specific studies that were conducted and are not associated with a specific laboratory or individual.

- **STATISTICAL PROBABILITY**

Data regarding the frequency of individual characteristics in the firearms population is not available, resulting in an inability to calculate the likelihood or statistical probability of a 'random match'. Current research in the discipline by NIST (National Institute of Standards and Technology), CSAFE (Centre for Statistics and Applications in Forensic Evidence), ULTRA Electronics Forensic Technology Inc., and other academic and research organizations to collect empirical data and establish a statistical basis for firearms identification is ongoing.

GENERAL ACCEPTANCE IN THE SCIENTIFIC COMMUNITY

Firearms Identification has been generally accepted amongst the forensic science community, especially under the realm of comparative sciences. The concern in the broader scientific community lies with the subjective opinion of identification or elimination when comparing two cartridge cases or bullets as having been fired by the same firearm. Firearms Identification methods and opinions have been accepted in the courts to date as the process of microscopic examination is objective and follows the scientific method to yield reliable and reproducible results. The opinion is subjective, but the examiner is able to opine an identification or elimination based on experience, training and knowledge of manufacturing processes.

Firearms Identification methodology yields reproducible results as proven by proficiency tests, verification processes, validation studies, consecutively manufactured firearm/parts studies and global participation in comparison studies.

[1] The 2% estimate includes false-positive and false-negative responses, but does not include inconclusive results.

QUALITY ASSURANCE PROCESSES

- **ACCREDITATION**

The CFS is an accredited laboratory. The activities of the CFS are carried out in accordance with the ISO/IEC 17025:2017 requirements for the competence of testing and calibration laboratories, the accrediting body's policies and requirements, and the policies and requirements of the Government of Ontario. Firearms and Toolmarks examinations are within the scope of services for which the CFS is accredited. The CFS strives to ensure that there is no undue influence from internal or external sources on the professional judgement or quality of work of its employees. The CFS has established procedures that safeguard the security of information, evidence, and the facility.

The CFS management system supports the delivery of accurate and reliable analyses and interpretations, and objective and relevant reports and testimony. It ensures that all staff recognize the importance of a high-quality standard and understand and apply all aspects of the quality system. It incorporates a commitment to continual assessment to improve and enhance quality and supports compliance with the International ISO/IEC 17025 standard.

The following types of documents comprise the management system: the quality manual, CFS-wide procedures, Section and Unit Procedures, training manuals, health and safety manual, forms and external documents.

- **TRAINING**

The ability of each staff member to perform their work is demonstrated through their academic qualifications, training, experience, and the successful completion of competency tests.

Firearms scientists undergo a rigorous training program prior to completing case work and reports for court. They complete training modules and are assessed using competency tests and oral examinations. Once trained and authorized to perform case work, firearms scientists must successfully complete annual proficiency tests.
During the training process, firearms scientists gain experience in recognizing patterns of markings by examining many fired ammunition components (bullets and cartridge cases) from the same firearm and from different firearms. They also examine ammunition components discharged in firearms that have been manufactured consecutively.

- **PROFICIENCY TESTS**

The ability of firearms scientists to reliably render conclusions in the area of firearms identification is continually tested and evaluated through the use of proficiency tests. Proficiency tests are samples that are provided to the firearms examiner to analyze in which the ground truth is known. There are three types of proficiency tests used at the CFS: external, internal and blind. The external proficiency tests are purchased from an external test provider and administered in the lab. The lab personnel know that it is a test, but do not know the expected

results. Internal proficiency tests are tests that are generated within the lab and administered. The test administrator is aware of the result, however the scientist that is tested is not aware of the result. Blind proficiency tests are created internally but administered in a method in which they cannot be distinguished from routine case work. The scientist is unaware that they are completing a test when they conduct the examination. All firearms scientists are required to participate in annual proficiency testing.

- **METHODOLOGY**

All case work that is completed is subject to the CFS Quality Assurance program requirements which includes such components as use of standard operating procedures when completing case work, visual verification of observations by a second qualified scientist, and technical review of case records.

- **MICROSCOPIC VERIFICATION**

Microscopic verification by a second qualified examiner is required for all full exam cases involving identifications and eliminations based on individual characteristics. The scientist who conducts the verification is not aware of the original examiner's results when they conduct the microscopic comparison.

- **PEER REVIEW/TECHNICAL REVIEWS**

Technical reviews must be conducted on all case records. The technical reviewer need not be currently qualified for case work in that area but must have been previously qualified to perform case work or testing in the tasks being reviewed, to verify compliance with the laboratory's technical procedures.