“An Empirical Study to Improve the Scientific Foundation of Forensic Firearm and Tool Mark Identification Utilizing 10 Consecutively Manufactured Slides”

Award Number 2009-DN-BX-K230

Final Report

Submitted By:

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2011

This project was supported by Award No. 2009-DN-BX-K230 awarded by the National Institute of Justice, Office of Justice Programs, U. S. Department of Justice. The opinions, findings, and conclusions or recommendations expressed in this publication/program/exhibition are those of the authors and do not necessarily reflect those of the Department of Justice.

Abstract

The Miami-Dade Police Department Crime Laboratory conducted a research study on the repeatability and uniqueness of striations/impressions on fired cartridge casings fired in 10 consecutively manufactured 9mm Ruger slides to improve understanding of the accuracy, reliability, and measurement validity in the firearm and tool mark discipline of forensic science. The foundation of firearm and tool mark identification is that each firearm/tool produces a signature of identification (striation/impression) that is unique to that firearm/tool, and through the examination of the individual striations/impressions, the signature can be positively identified to the firearm/tool that produced it. The National Academy of Sciences (NAS) Report questioned the repeatability and uniqueness of striations/impressions left on fired evidence as well as the validity and error rate in firearms identification. This study analyzed the repeatability and uniqueness of striations/impressions on fired cartridge cases fired in 10 consecutively manufactured Ruger slides by analyzing breech face striations/impressions through an evaluation of the participants' accuracy in making correct identifications. One semi-automatic pistol and nine additional consecutively manufactured slides were utilized. Consecutively manufactured slides are significant to this study because they were manufactured with the same equipment/tools, one right after the other. Even though these slides were consecutively made, their signatures should be different. Test sets included test fired casings from each slide, as well as unknowns. Participants were firearm & tool mark examiners throughout the United States. One hundred and fifty-eight test sets were distributed to laboratories in forty-six states and the District of Columbia. The test sets were designed to determine an examiner's ability to correctly identify unknown cartridge casings fired from 10 consecutively manufactured Ruger Slides to test fired cartridge casings fired from the same slides. This empirical study established an error rate of less than 0.1 percent. Durability testing established that the Ruger Slides maintained their individual signature after multiple firings.

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EXECUTIVE SUMMARY

The National Academy of Sciences Report (2009) questioned the repeatability and uniqueness of striations/impressions left on fired firearms evidence as well as the validity and error rate in firearms identification. The goals of this research study were: 1) to conduct an empirical study to evaluate the repeatability and uniqueness of striations/impressions imparted by consecutively manufactured slides; and 2) to determine the error rate for the identification of same gun evidence.

Utilizing an experimental research design, this study analyzed the repeatability and uniqueness of striations/impressions on cartridge cases fired in 10 consecutively manufactured slides by analyzing breech face striations/impressions. One semi-automatic pistol and nine additional consecutively manufactured slides were utilized. Consecutively manufactured slides are significant to this study because they were manufactured with the same equipment/tools. Even though these slides were consecutively made, their signatures should be different if there is no subclass influence. Test sets assembled included known test fired casings from each slide, as well as unknowns.

Participants were firearm & tool mark examiners throughout the United States. One hundred and fifty-eight test sets were distributed to laboratories in forty-six states and the District of Columbia. The test sets were designed to determine an examiner's ability to correctly identify cartridge casings fired from 10 consecutively manufactured Ruger slides to test fired cartridge casings fired from the same slides. This empirical study established an error rate of less than 0.1 percent. Durability testing established that the breech faces of the Ruger slide maintained their individual signature after multiple firings.

The National Academy of Sciences Report (2009) states that "some forensic science disciplines are supported by little rigorous systematic research to validate the discipline's basic premises and techniques." In addition, the report states that forensic science will be improved by collaborative opportunities "with the broader science and engineering communities." The statistical analyses of the research data was performed by a professor from the Department of Statistics at Florida International University. This collaboration with an external agency to analyze the data that was collected helps to ensure that the statistical results are reported accurately and without bias.

This research provides further support for the scientific foundation of forensic firearm and tool mark identification through the evaluation of unknown cartridge casings to determine the repeatability and uniqueness of striations/impressions. The error rate of identifications of same gun evidence was calculated from the data collected. This study provides empirical data to strengthen the foundation of firearms identification in both the firearm identification field and in the legal arena, thus addressing some of the National Academy of Sciences' concerns with how firearm and tool mark identifications are supported.

INTRODUCTION

Purpose, Goals and Objectives

The purpose of this research was to conduct an empirical study to evaluate the repeatability and uniqueness of striations/impressions imparted by consecutively manufactured slides to fired cartridge casings as well as to determine the error rate for the identification of same gun evidence.

Limited studies have previously been conducted on consecutively manufactured slides; however, no studies have been conducted in which test sets were sent to a large number of participants. The goal was to determine whether or not fired cartridge casings can be identified to the firearms that fired them through the comparison of tool marks.

The objective of this research study was to determine if firearm and tool mark examiners would be able to identify unknown casings to the firearms that fired them when examining casings fired through consecutively manufactured slides utilizing individual, unique and repeatable striations/impressions. Also, the study presented herein evaluated the experience level of firearm and tool mark examiners and the effect of their experience level on the results.

Review of Relevant Literature

A review of the relevant literature provides a multitude of examples of studies where one individual or a small group of individuals correctly identified casings fired consecutively in various firearms. These durability studies examined the repeatability and longevity of a firearm's unique signature. These studies are conducted by comparing the first test fire to the last test fire after the firearm has been fired at least several times in between. The research has demonstrated that a firearm's unique signature remains identifiable even after several thousand test fires.

Ogihara et al. (1983) examined 5,000 fired casings fired through one .45 Auto caliber pistol and correctly identified all of the fired casings to this pistol. Shem and Striupaitis (1983) conducted a durability study with one .25 Auto caliber pistol and reported that they were able to correctly identify the first fired casing to the 501st fired casing. Matty (1984) examined casings that were fired from three consecutively manufactured .25 Auto caliber slides and concluded that they could be identified with the correct slide. Thompson (1994) reported that he examined casings fired from four consecutively manufactured .25 Auto caliber slides and concluded that they could also be identified to the correct slides.

Hamby (2001) examined and correctly identified casings to the 617 firearms that fired them. Bunch and Murphy (2003) conducted a study at the FBI Laboratory utilizing 10 consecutively manufactured slides; they concluded that each slide produced a different signature. Coody (2003) examined and correctly identified fired casings from 10 consecutively manufactured Ruger pistol slides. Coffman (2003) examined and correctly identified fired casings from 10 consecutively manufactured breech bolts. Vinci et al. (2005) conducted a durability study utilizing one pistol and determined that they could correctly identify all 2,500 fired casings. Gouwe et al. (2008) conducted a durability study with one .40 caliber firearm and reported that they were able to identify fired casing one to fired casing 10,000.

No study has been conducted to identify casings from consecutively manufactured slides where the number of participants in the study reaches or exceeds one hundred. A larger sample size will lead to a more reliable estimate of the true error rate for the identification of same gun evidence by firearm and tool mark examiners.

RESEARCH DESIGN AND METHODS

This study utilized an experimental research design (Christensen, 2004; Creswell, 2005), and was conducted in a crime laboratory setting. Participants compared questioned casings to known standards that were fired in 10 consecutively manufactured slides in order to determine whether or not the consecutively manufactured slides differed from each other by producing different signatures, each with unique striations/impressions (tool marks). Durability testing was then conducted to determine if the individual signature of the slides changed due to repeated firing. This research study also established an error rate for the identification of same gun evidence.

Quantitative data was utilized to determine if the examiners could correctly identify questioned casings test fired in multiple consecutively manufactured slides. Additionally, the years of experience of the examiners was recorded. This data answered the following: 1) whether or not consecutively manufactured slides produced different individual signatures; 2) whether multiple firings changes the signature to the extent where it can no longer be identified; and 3) whether years of experience impacts correct identifications. Questionnaire/answer sheets were utilized to collect the quantitative data (see Appendices A and B).

The proposed outcome in this section is presented with the intention that the findings will be able to answer the research questions.

Research Questions

Q1. Will firearm and tool mark examiners be able to correctly identify the firearms that fired the questioned casings when examining casings fired through consecutively manufactured slides?

Q2. Will firearm and tool mark examiners with less than 10 years of experience reach the same conclusions as those with greater than 10 years of experience when examining casings fired through consecutively manufactured slides?

Q3. Will firearm and tool mark examiners be able to correctly identify the firearms that fired the questioned casings when examining casings fired at different intervals (durability study - after 361 to 995 test firings – see Durability Phase 2 Testing Study Definition on page 16) through consecutively manufactured slides?

Research Hypotheses

H1. Firearm and tool mark examiners will be able to correctly identify unknown casings to the firearms that fired them when examining casings fired through consecutively manufactured slides by utilizing individual, unique and repeatable striations/impressions.

H2. The experience level of firearm and tool mark examiners will not affect identification results when examining casings fired through consecutively manufactured slides.

H3. Firearm and tool mark examiners will be able to correctly identify unknown casings to the firearms that fired them when examining casings fired at different intervals through consecutively manufactured slides by utilizing individual, unique and repeatable striations/impressions.

There is one dependent variable that was examined in this study. The dependent variable is accuracy (proportion of incorrect identifications), which was measured by whether or not the questioned casings could be correctly identified to the consecutively manufactured slides by using individual, unique and repeatable striations/impressions.

There are several independent variables in this study, such as the consecutively manufactured slides, interval of firing and experience of the examiner. For Q1 and H1, the researchers were interested in studying the effect of the consecutively manufactured slides on the ability to identify same gun evidence. For Q2 and H2, the researchers were interested in studying the effect of the independent variable of experience, the knowledge and practical wisdom gained through study, observation, experimentation and case work, on the ability to identify same gun evidence. For Q3 and H3, the researchers were interested in studying the effect of the interval of firing on the ability to identify same gun evidence. Extraneous variables were controlled as much as possible by utilizing laboratory settings.

Using an experimental design, three research questions were explored in this study. Question one: Will firearm and tool mark examiners be able to correctly identify the firearms that fired the questioned casings when examining casings fired through consecutively manufactured slides? For question one, the dependent and independent variables were measured through the average error rate on the Consecutively Manufactured Slide Test Set Instrument Survey by a 1 to 15 point system (1 point for each correct answer, with a maximum point value of 15).

Question two: Will firearm and tool mark examiners with less than 10 years of experience reach the same conclusions as those with greater than 10 years of experience when examining casings fired through consecutively manufactured slides? For question two, the dependent and independent variables were measured through the average error rate on the Consecutively Manufactured Slide Test Set Instrument Survey by a 1 to 15 point system (1 point for each correct answer, with a maximum point value of 15).

Question three: Will firearm and tool mark examiners be able to correctly identify the firearms that fired the questioned casings when examining casings fired at different intervals (durability study) through consecutively manufactured slides? For question three, the dependent and independent variables were measured through the average error rate on the Consecutively Manufactured Slide Test Set Instrument Survey Phase 2 by a 1 to 5 point system (1 point for each correct answer, with a maximum point value of 5).

Three hypotheses were tested in this study. For the first hypothesis (H1), the dependent and independent variables measured whether or not consecutively manufactured slides produced individual, unique and repeatable striations/impressions based on each participant’s results. If the breech face tool mark signatures from each of the ten consecutively manufactured slides could be distinguished from one another by the participants, this would establish that there is no subclass tool mark influence present from the manufacturing process used to form the breech faces.

For the second hypothesis (H2), the dependent and independent variables measured whether or not the years of experience of the participants affected the ability of the examiners to identify same gun evidence based on each participant’s results.

For the third hypothesis (H3), the dependent and independent variables measured whether or not consecutively manufactured slides produced individual, unique and repeatable striations/impressions on casings fired at different intervals based on each participant’s results.

Target Population

In this study, the target population represented a subset of the forensic science community, more specifically, firearm and tool mark examiners employed by a law enforcement agency (crime laboratory), or like agency, in the United States. The Miami-Dade Police Department (MDPD) Crime Laboratory (CL) utilized the membership list for the Association of Firearm and Tool Mark Examiners (AFTE). Eleven members of this association currently work in the MDPD CL.

Membership in AFTE is limited to individuals with suitable education, training, and experience in the examination of firearms and/or tool marks. For purposes of this membership, a practicing firearm and/or tool mark examiner is defined by AFTE (2009) as: “(1) An individual who derives a substantial portion of his livelihood from the examination, identification, and evaluation of firearms and related materials and/or tool marks; and (2) An individual whose present livelihood is a direct result of the knowledge and experience gained from the examination, identification, and evaluation of firearms and related materials and/or tool marks.”

Every firearms examiner in the United States who is a member of AFTE had an equal opportunity to be included in this study. Each AFTE member was contacted by the MDPD CL via email inviting them to participate in this study, which included completing demographic questions and participation in an experimental exercise. The number of participants exceeded the recommended number based on the formula of $n > 50 + 8m$ (Green, 1991).

The test sets utilized in this study were similar to the work that the participants perform on a routine daily basis. The researchers at the MDPD CL are members of AFTE, and one of the privileges of membership is access to the membership list.

Eligibility-Inclusion Criteria

Participants were required to be firearm and tool mark examiners employed by a law enforcement agency (crime laboratory), or like agency, in the United States, and must have completed a two year training program. Independent examiners who retired from a qualifying agency were also eligible to participate in this study. Participants for the durability testing (questioned casings fired at different intervals) were required to have completed Phase 1 testing of this study.

Accessible Population

Accessibility was limited to firearm and tool mark examiners for whom the MDPD CL was able to obtain email addresses by querying the membership list for AFTE. This accounts for 92% of the 2010 AFTE Roster.

Sampling Plan and Setting

The sampling plan for this study utilized an abstract population. Every eligible firearm and tool mark examiner in the United States who is a member of AFTE, with a functional email address, was invited to participate in this research. The AFTE list identified participants that met the MDPD CL eligibility-inclusion criteria as stated above in Eligibility-Inclusion Criteria. The accessible population included approximately 800 firearm and tool mark examiners in the United States.

To ensure confidentiality, the researchers at the MDPD CL invited firearm and tool mark examiners to participate via email. The survey and test (see Appendices A and B) were conducted by each participant independently, which strengthened the study's validity (Gall & Borg, 1996).

Instrumentation

This study utilized two similar instruments, each of which included two methods of instrumentation: a questionnaire that included the participant's demographics, as well as an answer sheet for an experimental exercise. The questionnaires each took less than ten minutes to complete. The first experimental exercise took approximately two to eight hours to complete. The durability exercise took approximately two to four hours to complete. The above listed approximate times were based on personal communication and observation of participants from the MDPD CL.

The experimental exercise was originally utilized by Brundage (1998), and redesigned by Hamby (2001). Over 500 firearm and tool mark examiners have used this instrument (Hamby, Brundage and Thorpe, 2009). The researchers at the MDPD CL modified this instrument by replacing "barrel" with "slide." In addition, the number of years of experience for each firearm and tool mark examiner was added. Furthermore, the researchers at the MDPD CL added a category for pattern matching and quantitative consecutive matching striations (QCMS). Pattern matching and QCMS are two forms of striated tool mark examination/assessment processes used in the field of firearm and tool mark examination.

The instrument for the durability testing was modified further to include questions about certification and gender. Additionally, the category of “Inconclusive” was added for the experimental exercise.

Data Collection Methods

The researchers did the following:

1. Received National Institute of Justice (NIJ) approval.
2. Sent email to the AFTE membership. Participation was voluntary.
3. Obtained 1 pistol frame and 10 slides and labeled the slides 1 through 10.
4. Obtained 9mm cartridges (ammunition/bullets).
5. Utilized the MDPD CL indoor range for test firing and retrieval of the casings.
6. Placed each slide one at a time on the pistol frame.
7. Loaded the pistol with five cartridges.
8. Fired the pistol on the range.
9. Fired five cartridges through each slide to create one test set. (This was repeated 200 times per slide, 1,000 cartridges per slide in total).
10. Used secure, properly labeled, containers to keep each group of five casings separated.
11. Labeled two of the five casings with the number of the slide in which they were fired (1 through 10) to create the test fired casings (known standards). These known standards were placed in a labeled coin envelope.
12. Labeled remaining three casings with an alpha character designated by the researchers at the MDPD CL to represent the questioned casings (different alpha characters were assigned to each slide).

13. Selected one questioned casing from each slide randomly from the container and placed it in a labeled coin envelope.
14. Selected an additional five questioned casings to complete the test set of 15 questioned casings. These five casings were each placed in a labeled coin envelope.
15. Created 200 test sets and placed each test set in a medium manila envelope.
16. The researchers microscopically examined every 10th set to ensure that the casings were comparable and identifiable.
17. Mailed test sets to respondents. Each respondent received one test packet through the mail which included the following:
    - One questionnaire/answer sheet
    - 15 questioned casings
    - 10 sets of test fired casings (known standards) that were fired through the 10 consecutively manufactured slides.
18. Instructed the participants via the questionnaire/answer sheet to compare the questioned casings to the known standards, and to place their answers on the questionnaire/answer sheet.
    - The participants were also asked to complete the questions that were on the questionnaire/answer sheet.
    - The instructions directed the participants to mail the questionnaire/answer sheet or to fax it.
19. Conducted the data collection process for 26 weeks.
20. Utilized an Excel spreadsheet to record and analyze the data collected.

21. Submitted the data to a professor from the Department of Statistics at Florida International University for statistical analyses.

Durability Testing:

22. Sent email to participants who completed the first test. Participation was voluntary.
23. Used 1 pistol frame and 5 slides and labeled the slides.
24. Obtained 9mm cartridges (ammunition/bullets).
25. Utilized the MDPD CL indoor range for test firing and retrieval of the casings.
26. Placed each slide one at a time on the pistol frame.
27. Loaded the pistol with one cartridge.
28. Fired the pistol on the range.
29. Fired one cartridge through each slide to create one test set. (This was repeated 100 times per slide, 100 cartridges per slide in total).
30. Used secured, properly labeled containers to keep each casing separated.
31. Labeled each casing with an alpha character designated by the researchers at the MDPD CL to represent the questioned casing (different alpha characters from the first test were assigned to each slide).
32. Placed each questioned casing in a labeled coin envelope.
33. Created 100 test sets and placed each test set in a medium manila envelope.
34. Mailed test sets to participants. Each respondent received one test packet through the mail which included the following:
    - One questionnaire/answer sheet
    - 5 questioned casings

- Note: Each participant already had the test fired known standards from the first test.

35. Instructed the participants via the questionnaire/answer sheet to compare the questioned casings to the known standards (already in their possession) and to place their answers on the questionnaire/answer sheet.
    - The participants were also asked to complete the questions that were on the questionnaire/answer sheet.
    - The instructions directed the participants to mail the questionnaire/answer sheet or to fax it.
36. Conducted the data collection process for 6 weeks.
37. Utilized an Excel spreadsheet to record the data collected.
38. Submitted the data to a professor from the Department of Statistics at Florida International University for statistical analyses.

<u>Data Coding</u>

Phase 1 Testing

Each participant was assigned a number from 1 to end. There were 15 variables (questioned casings) which were designated with an alpha character and coded as correct (1), incorrect (2) or inconclusive (3). The overall correct number was coded 1 through 15 based on the correct number of identifications. Pattern matching was coded as 1, QCMS was coded as 2, utilization of both methods was coded as 3 and no answer was coded as 4. The type of microscope was coded 1 for Leica, 2 for Leeds, 3 for other, or 4 for no answer. Type of lighting was coded 1 for florescent, 2 for fiber optic, 3 for LED, 4 for other, or 5 for no answer. Years of experience was coded based on <10 (coded 1) and >10 (coded 2) years of experience.

Examination of other evidence was coded 1 for "yes," 2 for "no" and 3 for no answer. Professional or forensic organizations were coded 1 for "yes," 2 for "no" and 3 for no answer. FBI Specialized Techniques School was coded 1 for "yes," 2 for "no" and 3 for no answer. The number of years of training was coded 1 for 2 years or more and 2 for < 2 years. The type of training was coded into 4 groups, 1 for in-house/structured, 2 for National Firearms Examiner Academy, 3 for other, and 4 for no answer. Individuals trained in QCMS were coded 1 for "yes," 2 for "no" and 3 for no answer (see Appendix A).

Phase 2 Testing (Durability)

Each participant was assigned a number from 1 to end. There were 5 variables (questioned casings) which were designated with an alpha character and coded 1 as correct, 2 as incorrect or 3 as inconclusive. The overall correct number was coded 1 through 5 based on the correct number of identifications. Pattern matching was coded as 1, QCMS was coded as 2, utilization of both methods was coded as 3 and no answer was coded as 4. Type of microscope was coded 1 for Leica, 2 for Leeds, 3 for other, or 4 for no answer. Type of lighting was coded 1 for florescent, 2 for fiber optic, 3 for LED, 4 for other, or 5 for no answer. Gender was coded 1 for male, 2 for female and 3 for no answer. AFTE certification was coded 1 for "yes," 2 for "no" and 3 for no answer. ABC certification was coded 1 for "yes," 2 for "no" and 3 for no answer. Other certification was coded 1 for "yes," 2 for "no" and 3 for no answer (see Appendix B).

Descriptive Analysis

Descriptive analysis was used to describe the participants. Descriptive analysis for Phase 1 and Phase 2 testing included years of experience, method used (pattern matching/QCMS), as well as the type of microscope and lighting used.

Data Analysis Methods

Simple descriptive scores were used to analyze all variables. Next, correlation statistics were performed utilizing a statistical program, S-PLUS, to answer the three research questions. An independent statistician performed the data analyses.

Error Rate Definition

An error rate is a calculated value that represents the comparison of the number of wrong responses with the total number of responses. The error rate for each participant was defined as the proportion of questions answered incorrectly by that participant. For example, if a participant answered 5 out of the 15 questions incorrectly, their error rate is 0.3333. An average error rate is calculated by dividing the sum of the error rates per respondent by the total number of respondents. An average error rate calculation was used for both phase 1 and phase 2 of this study. An average error rate calculation was used by the researchers because it is illustrative of the error rate across all participants rather than solely based on number of responses.

Durability Phase 2 Testing Study Definition

The purpose of a durability test is to evaluate the robustness of repeatable, unique and identifiable striations. Each participant received 5 additional questioned casings with a new answer sheet. The participants were asked to compare these five questioned casings to the known standards that they previously received with the original test set. Each slide had already been fired 1,000 times prior to the 5 additional questioned casings created for the durability study. For example, to create test 1, each slide was used to fire 5 cartridge casings. A total of 995 additional casings were fired through these slides to create the test sets. Therefore, when the durability test set was created for the first test of Phase 2, there were a total of 995 rounds fired through each slide between the creation of the known standards for test 1 and the 5 additional questioned casings fired for the durability study (Phase 2). Each durability test set followed the same sequence.

Internal Validity Strengths

- The quantitative data was internally valid due to the procedures set forth to assemble the tests.
- All the test materials were assembled in a crime laboratory setting.
- All questioned casings and known standard casings were labeled with a number (standard) or letter (questioned casings).
- Secure containers were used to keep the questioned casings separated into groups.
- The researchers at the MDPD CL microscopically examined every 10th test set to ensure that the casings were comparable and identifiable.
- The questionnaire/answer sheet used has been documented in previous studies, and is a standardized format.

Internal Validity Weaknesses

- The validity of this study was dependent upon the accuracy of the assembly of the tests.
- Communication between participants could have threatened the internal validity.
- The possibility exists that the questioned casings and known standards failed to mark clearly. Since every set was not microscopically examined to ensure that the casings were comparable and identifiable, some sets may have contained casings that were not suitable for identification.

External Validity Strengths

- The external validity strength of this research project was that all testing was conducted in a crime laboratory setting.

- Participants utilized a comparison microscope.
- The participants were trained firearm and tool mark examiners.
- The training and experience of the participants strengthened the external validity.
- The researchers exceeded the sample size.

External Validity Weaknesses

- The researchers assumed that the participants followed appropriate AFTE procedures, as listed in the AFTE Procedures Manual, FA-IV-13, Microscopic Comparison (2001).
- The researchers had no control over the equipment used by the participants.
- The training and skill level as well as the experience of the participants could have been an external weakness.
- The participants could have used the well defined firing pin aperture shear striated tool marks since these were adjacent to the breech face marks.
- Circled responses on the Phase 1 answer sheet were marked as correct or incorrect. The Phase 1 answer sheet did not have a designated area to list inconclusive results. However, some examiners did list inconclusive results in the margins of the Phase 1 answer sheet. For Phase 2, a designated area for inconclusive results was present. Correct, not correct, and inconclusive were the three tabulated responses. If no alpha character was selected, it was considered an inconclusive answer. No eliminations were reported on either Phase 1 or Phase 2.
- The participants were not told whether the questioned casings constituted an open or closed set. However, from the questionnaire/answer sheet, participants could have assumed it was a closed set and that every questioned casing should be associated with one of the ten slides.

RESULTS

In this section, the examination of research questions, hypotheses testing, and other findings related to this study were analyzed to evaluate the repeatability and uniqueness of striations/impressions imparted to consecutively manufactured slides as well as to determine the error rate for the identification of same gun evidence. Participant performance (experimental exercise) relating to accuracy and demographic characteristics relating to the participants' ability to perform the experimental exercises were examined.

For this research study regarding participant performance relating to accuracy and methods utilized, a mass email was sent out to the membership of the Association of Firearm and Tool Mark Examiners. A total of 281 examiners representing 157 crime laboratories in 46 states, including the District of Columbia, completed the *Consecutively Manufactured Slide Test Set* questionnaire/answer sheet. Sixty-four of the 281 participants did not meet the two year training requirement for this study. This resulted in a data-producing sample of 217 participants for Phase 1 testing. Additionally, 114 participants completed the Phase 2 testing (Durability) *Consecutively Manufactured Slide Test Set* questionnaire/answer sheet.

The firearm and tool mark examiners that responded to the *Consecutively Manufactured Slide Test Set* questionnaire/answer sheet represented 92% of the states in the United States that conduct firearm and tool mark examinations.

The questionnaire/answer sheet instrument utilized for this study allowed the participants to record their answer by circling the appropriate alpha designator of the unknown casings on the same line as the known test fired casing sets designated by a numerical number 1 – 10 (Brundage, 1998; Hamby, 2001; Hamby & Brundage, 2007, 2009; Fadul 2011). This experimental exercise of the instrument was designed to measure accuracy.

The statistician utilized the statistical analysis program S-PLUS for this study. Nonparametric tests, namely the Wilcoxon Signed Rank test, the Wilcoxon rank Sum Test and the Kruskall Wallis tests were used for the analysis. The Wilcoxon Signed Rank test is a nonparametric alternative to the paired Student's t-test, the Wilcoxon Rank Sum test is used for comparing two independent samples while the Kruskall Wallis test is used for more than two independent samples. The tests are used when sample populations cannot be assumed to follow a normal distribution. Quite often these tests are based on ranks. As an example, when comparing two independent samples from populations A and B, one would first combine the two samples and rank their tested values (number of incorrect responses, for example) from the lowest to the highest. The lowest observation gets rank 1, the next one rank 2, etc. After ranking the combined sample, one would separate the samples and sum up the ranks of each (say A or B). If the populations are roughly similar, there should be no significant difference in the sum of the ranks (adjusted for sample size). This is the basis for the Wilcoxon Ranked Sum test. The Kruskall Wallis test extends this concept to more than two populations.

The National Academy of Sciences Report (2009) states that "some forensic science disciplines are supported by little rigorous systematic research to validate the discipline's basic premises and techniques." In addition, the report states that forensic sciences will be improved by collaborative opportunities "with the broader science and engineering communities." The statistical analyses of this research data was performed by Dr. Sneh Gulati, a professor from the Department of Statistics at Florida International University. This collaboration with an external agency to analyze the data that is collected helps to ensure that the statistical results are reported accurately and without bias.

Instrument Parameters

Each participant received a total of 10 pairs of known test fired casings labeled Slide 1 through Slide 10 and 15 questioned unknown fired casings labeled with an alpha character. The participants examined and compared the 15 questioned unknown fired casings to the 10 pairs of known test fired casings, which were labeled Slide 1 through Slide 10, and were asked to determine which slides were used to fire the 15 questioned unknown fired casings.

For the durability study, each participant received 5 additional questioned casings with a new questionnaire/answer sheet. The participants examined and compared the five questioned unknown fired casings to the 10 pairs of known test fired casings that they previously received, which were labeled Slide 1 through Slide 10, and were asked to determine which slides were used to fire the five questioned unknown fired casings.

Main Analyses

The first research question asked whether firearm and tool mark examiners would be able to identify the firearms that fired the questioned casings when examining casings fired through consecutively manufactured slides. In the null hypothesis, the average error rate (as previously defined) is zero versus the alternate hypothesis in which the error rate is greater than zero. The overall average error rate was 0.000636 and the standard error was 0.006617. All analyses in the study were conducted through nonparametric methods. The Wilcoxon Signed Rank Test was used to answer the first question. With a significance level of 0.05, the p-value was 0.079, and the error rate is not significantly different from zero. Inconclusive results were not counted in the calculation of the overall average error rate.

The second research question asked whether firearm and tool mark examiners with less than 10 years of experience would reach the same conclusions as those with greater than 10 years of experience when examining casings fired through consecutively manufactured slides. Nonparametric tests on the error rate between the two populations of experience (< 10 years = 1; > 10 years = 2) were conducted. Again, inconclusive results were not counted. The Wilcoxon Rank Sum test (nonparametric test) was utilized due to the possible lack of normality. The p-value was 0.9426. The high p-value indicates that the examiners with less than 10 years of experience will not reach different conclusions than the examiners with greater than 10 years of experience. As found in Table 1, there was no significant difference in the error rate between the two populations.

Table 1

Comparison Between Years of Experience Results

	YRS EXP = 1	YRS EXP = 2
$\overline{X}$	0.0006536	0.00062111
s	0.00601	0.00666

The third research question asked whether firearm and tool mark examiners would be able to identify the firearms that fired the questioned casings when examining casings fired at different intervals (durability) through consecutively manufactured slides. In the null hypothesis, the average error rate for Phase 2 testing (Durability) is zero; the alternative hypothesis is that the error rate for Phase 2 testing (Durability) is greater than zero. The Wilcoxon Signed Rank Test (nonparametric test) was utilized to determine whether the error rate was significantly higher than 0. There was a total of 114 data points. The overall average error rate was 0.0017699. The standard deviation was 0.0188, and the p-value was 0.3216. Inconclusive results were not counted in the calculation of the overall error rate.

Additional Analyses

This research study was not designed to carry out all of the below listed analyses. These analyses will serve as a guideline for future research studies. The error rates for these analyses were not significantly different from zero.

Analyses were conducted to determine if the type of microscope, lighting and/or method affected the error rate for Phase 1 testing. The Kruskal Wallis Test, which is nonparametric, was utilized. For each parameter, the null hypothesis was that the ability to identify same gun evidence would not be affected. The significance level was 0.05.

- Is the error rate different for different types of lighting? The p-value was 0.3047.
- Is the error rate different for different microscopes? The p-value was 0.3883.
- Is there a difference in the error rate due to different methods? The p-value was 0.8297.

Analyses were conducted to determine if the type of microscope, lighting and/or method affected the error rate for Phase 2 testing. The Kruskal Wallis Test was utilized for the microscope, lighting and method. For each parameter, the null hypothesis was that the ability to identify same gun evidence would not be affected. The significance level was 0.05.

- Does the error rate depend on the lighting? The p-value was 0.9082.
- Does the error rate depend on the type of microscopes used? The p-value was 0.8878.
- Does the error rate depend on the method being used? The p-value was 0.715.

Based on the above listed p-values for both Phase 1 and Phase 2 testing, no significant difference in error rates was observed as a function of variation in lighting, microscope or method.

Inconclusive Results

Inconclusive answers were not used to calculate the overall average error rates for Phase 1 and Phase 2 testing because they were not considered errors. According to Peterson and Markham (1995), inconclusive answers are neither incorrect nor correct and may indeed be the most appropriate response in a situation in which the sample, lab policy, and/or examiner capabilities do not permit a more definitive conclusion.

Summary of Results

The first research question asked if firearm and tool mark examiners would be able to correctly identify the firearms that fired the questioned casings when examining casings fired through consecutively manufactured slides. The dependent variable (accuracy) and the independent variable (consecutively manufactured slides) were measured by whether or not the questioned casings could be correctly identified to the consecutively manufactured slides by using individual, unique and repeatable striations/impressions (proportion of incorrect identifications). The analysis of the data revealed that the error rate was not significantly different from zero (0.000636).

The second research question asked if firearm and tool mark examiners with less than 10 years of experience would reach the same conclusions as those with greater than 10 years of experience when examining casings fired through consecutively manufactured slides. The dependent variable (accuracy) was compared against the independent variable of years of experience (knowledge and practical wisdom). The analysis of the data revealed that there were no significant differences between the two groups (less than 10 years of experience, 0.0006536, and greater than 10 years of experience, 0.00062111) and their ability to identify same gun evidence.

The third research question asked if firearm and tool mark examiners would be able to correctly identify the firearms that fired the questioned casings when examining casings fired at different intervals through consecutively manufactured slides (durability). The dependent variable (accuracy) and the independent variable (interval of firing) were measured by whether or not the questioned casings could be correctly identified to the consecutively manufactured slides by using individual, unique and repeatable striations/impressions (proportion of incorrect identifications). With a significance level of 0.05, the error rate was not significantly different from zero (0.0017699).

Demographic variables analyzed included the type of lighting, type of microscope and method. These variables were analyzed to determine if they affected the error rate. With a significance level of 0.05, the type of lighting, type of microscope, and method did not significantly affect the error rate.

The first hypothesis states that firearm and tool mark examiners will be able to correctly identify unknown casings to the firearms that fired them when examining casings fired through consecutively manufactured slides by utilizing individual, unique and repeatable striations/impressions. The findings of this research study support this hypothesis. With a significance level of 0.05, the data revealed that the error rate was not significantly different from zero.

The second hypothesis states that the experience level of firearm and tool mark examiners will not affect identification of same gun evidence when examining casings fired through consecutively manufactured slides. The findings of this research study support this hypothesis. Based on this study, the experience level of the firearm and tool mark examiner did not affect the firearm and tool mark examiner's examination/comparison conclusions when examining casings fired through consecutively manufactured slides. With a significance level of 0.05, the analysis of the data revealed that there were no significant differences between the two groups of examiners

The third hypothesis states that firearm and tool mark examiners will be able to correctly identify unknown casings to the firearms that fired them when examining casings fired at different intervals through consecutively manufactured slides by utilizing individual, unique and repeatable striations/impressions. The findings of this research study support this hypothesis. With a significance level of 0.05, the error rate was not significantly different from zero.

The findings of this research study supports the theory in firearm and tool mark identification, that, assuming no subclass influences, each firearm/tool produces a signature of identification (striation/impression) that is unique to that firearm/tool. Through examining the individual striations/impressions, the signature can be positively identified to the firearm/tool that produced it. Such tool mark identifications are made to a practical certainty. These identifications are not absolute because it will never be possible to examine every firearm or tool in the world, a prerequisite to making absolute determinations. The conclusion that "sufficient agreement" exists between two tool marks (test and questioned) for identification means that the likelihood that another tool (firearm) could have made the questioned tool mark is so remote as to be considered a practical impossibility.

Practical impossibility currently cannot be expressed in mathematical terms. As a result of extensive empirical research and validation studies, such as this one, that have been conducted in the field of firearm and tool mark identification, as well as the cumulative results of training and casework examinations that have been either performed or peer reviewed by the examiner, an opinion can be justifiably formed that it is a practical impossibility that another firearm will be found that exhibits as much individual microscopic agreement with test tool marks as the questioned tool marks that have been identified.

For Phase 1 testing, there were a total of 3,255 questioned unknown fired casings examined by the participants. There were 3,239 correct answers, 2 incorrect answers and 14 inconclusive answers. Table 2 illustrates the number of incorrect and inconclusive results. A total of 211 of 217 participants correctly identified same gun evidence. Two different participants reported incorrect answers. One of the two participants who reported an incorrect answer also reported one inconclusive answer. Two participants reported five inconclusive answers each. Another participant reported two inconclusive answers. Finally, one participant reported one inconclusive answer.

Table 2

Phase 1: Incorrect and Inconclusive Results

	Participants	**Incorrect Responses**	**Inconclusive Responses**
	n = 217		
	1	1	1
	1	1	0
	1	0	1
	1	0	2
	2	0	5
	211	0	0
Total	**217**	**2**	**14**

For Phase 2 testing (Durability), there were a total of 570 questioned unknown fired casings examined by the participants. There were 564 correct answers, 1 incorrect answer and 5 inconclusive answers. Table 3 illustrates the number of incorrect and inconclusive results. A total of 112 of 114 participants correctly identified same gun evidence. One participant reported one incorrect answer. Furthermore, another participant reported five inconclusive answers.

Table 3

Phase 2: Incorrect and Inconclusive Results

	Participants	Incorrect Responses	Inconclusive Responses
	n = 114		
	1	1	0
	1	0	5
	112	0	0
Total	**114**	**1**	**5**

The error rate for this research study was computed on an individual level for all participants and then averaged.

CONCLUSIONS

This research study provided pertinent information relative to the forensic science community and the forensic science discipline of firearm and tool mark identification. This research study was the first investigation to utilize multiple participants (over 200) to examine fired casings from consecutively manufactured slides in order to determine an error rate. Results from this study show that firearm and tool mark examiners can accurately identify casings that were fired through consecutively manufactured slides utilizing individual (no subclass influence), unique and repeatable striations/impressions.

Consecutively manufactured slides represent a situation where the same tools and machining processes are utilized back-to-back on one slide after another. This represents a situation where the most similarity should be seen between slides. If there were ever any chance for duplication of individual marks, it would have occurred here.

The results of this research study, as well as past studies, indicate that sufficient empirical evidence exists to support the scientific foundation of firearm and tool mark identification, in which, once the specter of subclass influence is eliminated, each firearm/tool produces a signature of identification (striation/impression) that is unique to that firearm/tool. Through the examination of the individual striations/impressions, the tool mark signature can be positively identified to the firearm/tool that produced it (Ogihara et al., 1983; Shem & Striupaitis, 1983; Matty, 1984; Thompson, 1994; Hamby, 2001; Bunch & Murphy, 2003; Coody, 2003; Coffman, 2003; Vinci et al., 2005; Gouwe et al., 2008).

This research also indicates that firearm and tool mark examiners will be able to correctly identify unknown casings to the firearms that fired them when examining casings fired at different intervals through consecutively manufactured slides utilizing individual, unique and repeatable striations/impressions.

Data also revealed no significant differences in the error rate between identifications made by firearm and tool mark examiners with < 10 years of experience (0.0006536, n = 102) as compared to identifications made by examiners with > 10 years of experience (0.00062111, n = 115) when examining casings fired through consecutively manufactured slides. These results indicate that a trained firearm and tool mark examiner with two years of training, regardless of experience, will correctly identify same gun evidence.

The most significant finding in this study was the low error rate for the examination of unknown casings and identification to the firearms that fired them when examining casings fired through consecutively manufactured slides utilizing individual, unique and repeatable striations/impressions. The error rate of the participants was established by Dr. Gulati to be 0.000636 for the initial test and 0.0017699 for the durability testing. Both error rates are not significantly higher than zero.

Finally, this research study addressed concerns that were raised by the National Academy of Sciences Report (2009). The National Academy of Sciences Report questioned the repeatability and uniqueness of striations/impressions left on fired evidence used to identify same gun evidence as well as the error rate in firearms identification. Based on this research study, firearm and tool mark examiners demonstrated a very low error rate when comparing casings fired in consecutively manufactured slides.

Limitations

The researchers discovered the following limitations to this study:

- The same firing pin was not used to fire all of the known and unknown casings.
- The researchers assumed that the participants followed appropriate AFTE procedures, as listed in the AFTE Procedures Manual, FA-IV-13, Microscopic Comparison (2001).
- Each participant was administered the experimental exercise at their own crime laboratory via mail, and the researchers had no observable control.
- The researchers had to assume that each participant independently completed the experimental exercise with no outside assistance.
- The researchers had no control of the equipment that participants utilized for the experimental exercise.
- The researchers had to assume that the equipment utilized was appropriate, properly maintained and properly functioning.
- The researchers had no control over the training, skill level or experience of the participants.

- The instrument for the experimental and durability exercises was individually administered utilizing the United States Postal Service according to the email response of the participants. All eligible firearm and tool mark examiners were invited to participate.
- While the researchers personally mailed the experimental exercise to one participant per crime laboratory, that participant in turn maintained control of the exercise. The researchers had no observable control.
- The issue of accreditation was not addressed in this research study.
- The researchers had no control of the development and maintenance of standards utilized by the participants' laboratories.
- The researchers did not examine the function of individual certification in firearm and tool mark examination/identification in this research study. This information was not captured during the Phase 1 testing.
- The participants could have assumed, due to the format of the questionnaire/answer sheets and no directions to the contrary, that each set of unknowns was closed, such that each unknown casing should properly be associated with one of the test slides.

Recommendations for Future Research

Future research is needed in the forensic science community in the area of multiple consecutively manufactured slides. Considerable research has been conducted on multiple consecutively manufactured slides/breech faces (Ogihara et al., 1983; Shem & Striupaitis, 1983; Matty, 1984; Thompson, 1994; Hamby, 2001; Bunch & Murphy, 2003; Coody, 2003; Coffman, 2003; Vinci et al., 2005; Gouwe et al., 2008); however, the present research study was the first investigation to utilize multiple participants (over 200) to examine fired casings from consecutively manufactured slides in order to determine an error rate. Participants from 157 crime laboratories in 46 states plus the District of Columbia participated in this study, and additional participants from the remaining crime laboratories and states should be sought out. Future research should include a re-test of the original participants to examine repeatability of the results.

Future research should analyze the repeatability and uniqueness of striations/impressions. Additional recommendations include the following:

- Other calibers of firearms should be examined.
- Both fired bullets and casings should be examined.
- Striated tool marks should be examined utilizing the comparison methods of pattern matching and QCMS to determine if there is a difference in error rates.
- The effect of membership in professional organizations should be investigated to determine if there is an impact on results.
- The topic of accreditation should be explored to determine if accreditation of the participant's laboratory has any effect on the examination and comparison of firearm and tool mark evidence.
- Examine whether individual certification affects the outcome of the examination and comparison of firearm and tool mark evidence.
- Use an "open set" design where the participant has no expectation that all questioned tool marks should match one or more of the unknowns.

Additional research will continue to improve the scientific foundation of forensic firearm and tool mark identification through evaluation, testing and study to determine the uniqueness of striations/impressions. Furthermore, it will allow the error rates for identifications of same gun evidence to be calculated from the additional data. Fundamental research will continue to improve the understanding of the accuracy, reliability and validity of the forensic science discipline of firearm and tool mark identification.

ACKNOWLEDGMENTS

Thank you to Dr. James Hamby who permitted the researchers to adapt the Consecutively Rifled P85 Barrel Test Set Survey/Answer Sheet.

Miami-Dade Police Department Crime Laboratory Firearm and Tool Mark Examiners:

- Chris Barr
- Jorge Bello
- Jill Errickson
- Yamil Garcia
- Angela Garvin
- George Hertel
- Julie Knapp
- John Mancini
- Magen Roberts
- Jami Taylor
- Tim Wilmot
- Erin Wilson

DISSEMINATION OF RESEARCH FINDINGS

NIJ 2011 Grantees Meeting Presentation, February 22, 2011, Chicago, IL.

AFTE 2011 42nd Annual Training Seminar, May 29 – June 3, 2011, Chicago, IL.

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Appendix A:

Survey Instrument (Questionnaire/Answer Sheet)

Miami-Dade Police Department
C r i m e   L a b o r a t o r y

9105 NW 25th Street, Miami, Florida 33172
(305) 471-2050

Firearm & Toolmark Unit

Answer Sheet: Consecutively Manufactured Slide Test Set Test Number: ________________

Name:________________________________Job Title:___________________________Date:________________

Years Experience:______________Years Training:____________Type of Training:_________________________

Brand & Model of Microscope:__________________________Type of Lighting:___________________________

Do you examine other types of evidence: Yes No If Yes, what other types?_______________________________
____

Do you belong to a professional or forensic organization(s)? Yes No Please list:__________________________

Have you attended the FBI Specialized Techniques School? Yes No CMS Trained? Yes No

Did you use Pattern Matching or CMS for this test? ____

Please microscopically compare the known test shots from each of the 10 slides (numbered 1 through 10) with the 15 questioned casings (scribed A through Z) submitted. Indicate your conclusion(s) by circling the appropriate 'alpha' designator on the same line as the known test shots indicated. Note: This test does not have to be done all at one time, but sufficient time to adequately examine this material is necessary. Although the casings have been scribed on the body, you may elect to confirm the 'identifier' and re-scribe it. Note: This test was developed to evaluate an examiner's ability to identify fired casings based on breech face marks solely. Do not use other markings (firing pin impressions, extractor marks, ejectors marks, chamber marks, etc.) for your comparisons, as they may be misleading.

Knowns Unknowns

1. A…B…C…D…E…F…G…H…I…J…K…L…M…N…O…P…Q…R…S…T…U…V…W…X…Y…Z
2. A…B…C…D…E…F…G…H…I…J…K…L…M…N…O…P…Q…R…S…T…U…V…W…X…Y…Z
3. A…B…C…D…E…F…G…H…I…J…K…L…M…N…O…P…Q…R…S…T…U…V…W…X…Y…Z
4. A…B…C…D…E…F…G…H…I…J…K…L…M…N…O…P…Q…R…S…T…U…V…W…X…Y…Z
5. A…B…C…D…E…F…G…H…I…J…K…L…M…N…O…P…Q…R…S…T…U…V…W…X…Y…Z
6. A…B…C…D…E…F…G…H…I…J…K…L…M…N…O…P…Q…R…S…T…U…V…W…X…Y…Z
7. A…B…C…D…E…F…G…H…I…J…K…L…M…N…O…P…Q…R…S…T…U…V…W…X…Y…Z
8. A…B…C…D…E…F…G…H…I…J…K…L…M…N…O…P…Q…R…S…T…U…V…W…X…Y…Z
9. A…B…C…D…E…F…G…H…I…J…K…L…M…N…O…P…Q…R…S…T…U…V…W…X…Y…Z
10. A…B…C…D…E…F…G…H…I…J…K…L…M…N…O…P…Q…R…S…T…U…V…W…X…Y…Z

Adapted from the International Forensic Science Laboratory with the permission of Dr. James E. Hamby

Appendix B:

Survey Instrument (Phase 2 Questionnaire/Answer Sheet)

Miami-Dade Police Department

C r i m e   L a b o r a t o r y

9105 NW 25th Street, Miami, Florida 33172
(305) 471-2050

Firearm & Toolmark Unit

Answer Sheet – Phase 2:
Consecutively Manufactured Slide Test Set

Test Number: _________________

Name: ________________________________ Date:________________

Brand & Model of Microscope:__________________________Type of Lighting:___________________________

AFTE Certified? Yes No ABC Certified? Yes No Other Certification? ___________________

Male or Female? (Please circle one)

Did you use Pattern Matching, CMS or Both for this test? ____

You must have completed the first test set in order to participate in this 2nd phase of the research study.

Please microscopically compare the known test shots from each of the 10 slides (numbered 1 through 10) with the 5 questioned casings (scribed A through Z) submitted. Indicate your conclusion(s) by circling the appropriate ‘alpha’ designator on the same line as the known test shots indicated. Note: This test does not have to be done all at one time, but sufficient time to adequately examine this material is necessary. Although the casings have been scribed on the body, you may elect to confirm the ‘identifier’ and re-scribe it. Note: This test was developed to evaluate an examiner’s ability to identify fired casings based on breech face marks solely. Do not use other markings (firing pin impressions, extractor marks, ejectors marks, chamber marks, etc.) for your comparisons, as they may be misleading.

Knowns Unknowns

1. A…B…C…D…E…F…G…H…I…J…K…L…M…N…O…P…Q…R…S…T…U…V…W…X…Y…Z
2. A…B…C…D…E…F…G…H…I…J…K…L…M…N…O…P…Q…R…S…T…U…V…W…X…Y…Z
3. A…B…C…D…E…F…G…H…I…J…K…L…M…N…O…P…Q…R…S…T…U…V…W…X…Y…Z
4. A…B…C…D…E…F…G…H…I…J…K…L…M…N…O…P…Q…R…S…T…U…V…W…X…Y…Z
5. A…B…C…D…E…F…G…H…I…J…K…L…M…N…O…P…Q…R…S…T…U…V…W…X…Y…Z
6. A…B…C…D…E…F…G…H…I…J…K…L…M…N…O…P…Q…R…S…T…U…V…W…X…Y…Z
7. A…B…C…D…E…F…G…H…I…J…K…L…M…N…O…P…Q…R…S…T…U…V…W…X…Y…Z
8. A…B…C…D…E…F…G…H…I…J…K…L…M…N…O…P…Q…R…S…T…U…V…W…X…Y…Z
9. A…B…C…D…E…F…G…H…I…J…K…L…M…N…O…P…Q…R…S…T…U…V…W…X…Y…Z
10. A…B…C…D…E…F…G…H…I…J…K…L…M…N…O…P…Q…R…S…T…U…V…W…X…Y…Z

Inconclusive:____

Adapted from the International Forensic Science Laboratory with the permission of Dr. James E. Hamby

Appendix C:

Sturm Ruger Certification Letter

STURM, RUGER & CO., INC.

200 RUGER ROAD • PRESCOTT, AZ 86301 U.S.A. • 928-778-6555 928-778-6633 (fax) • www.ruger.com

February 16, 2010

Gabriel A. Hernandez, M.S.
Criminalist Supervisor
Miami-Dade Police Department
Crime Laboratory Bureau
9105 NW 25th Street, Room 2159
Doral, Florida 33172-1500

Dear Mr. Hernandez,

Please accept this letter as certification that the broaching operation of the breech face on the 10 slides, marked 1 through 10, were, broached in sequential order using the same cutting tool as witnessed by my Production Control Technician Paul Kennedy and Inspector Linda Coleman.

These slides are for the Model P95PR15 pistol serial number 317-29816.

Respectfully

James D. Elliott
Plant Manager
Sturm, Ruger and Co., Inc.
200 Ruger Road
Prescott, Arizona 86301
928-541-8808'
jdelliott@ruger.com

Appendix D:

Manufacturing Information

Manufacturing Information

The following questions were asked by the researchers and the answers were provided by Rich David and James Elliot (Private Communication, 2011), Sturm, Ruger & Company, Inc.

Question One
What type of broach was used? Was it a step broach, for example, which was fit into the breech face recess and drawn across the breech face surface removing circular milling lines and leaving parallel straight lines? Is this done by hand? A previous paper on consecutively made Ruger slides (Coody, 2008) mentions a "Barrette file" being used to create the parallel lines on P89 slides.

Answer One
It is a horizontal hydraulic step broach, which uses broach oil for a lubricant / coolant. The slide is a cast part and since it is a straight pull broach, no circular milling lines are on the breech face. The only other machining to that surface is the firing pin hole which is done prior to broaching. The broach does, however, make parallel lines in the face since the individual broach bar cutters can vary a little because of sharpening.

Question Two
After the broaching operation, is there any other final finishing done to the breech area…particularly a filing or belt sanding operation to remove burrs? Or are the slides moved onto some sort of tumbling/ sand blasting step?

Answer Two
No other files or sanders touch the breech face on a P95. The firing pin hole gets chamfered after heat treat at the end of the slide process prior to bluing. This is done manually with a tool going through the barrel hole, similar to a long, thin screwdriver with a special tip to break the sharp edge of the firing pin hole to the breech face. This prevents that sharp edge from shaving brass off the cartridge primers which could eventually cause a misfire.

Question Three
Are the slides tumbled prior to hardening? If so, is it done with ceramic beads in a bowl vibrating method?

Answer Three
The slides are only tumbled AFTER heat treat using ceramic media in a vibratory bowl.

Question Four
Are the slides sand or bead blasted prior to hardening? If so, is the breech area protected during this? If it is protected, how so? With a plastic film? Is the plastic film pitted by the beads and can the breech underneath therefore be marred slightly by this pitting?

Answer Four
The slides are only sandblasted and bead blasted AFTER heat treat. There is no protection to the breech face during this process.

Question Five
Was the broach sharpened at any time during the manufacturing of the 10 slides sent to the MDPD Crime Laboratory? Also, how often are the broaches sharpened?

Answer Five
The broach was not sharpened during the 10 piece run. They usually can go 1,000 parts between sharpening although there are a lot of conditions that could affect the life between re-sharpen.

Question Six
We noted that you mentioned that the slides are tumbled after heat treat and that they are also sandblasted and bead blasted after heat treat. What is the actual order of events after heat treat?

Answer Six
The finish process sequence is as follows: heat treat, pickle in hydrochloric acid to remove any heat treat scale, tumble, sand blast, bead blast, and bluing.