The Identification of Consecutively Manufactured Extractors

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Key Words: Cartridge case, consecutive manufacture, criteria, extractor, identification, known non-match, semi-automatic pistol, striated toolmark, sub-class characteristics.

ABSTRACT

Caspian Arms, Ltd. produced ten consecutively manufactured extractors for use in a Colt, Model 1911A1 semi-automatic pistol. These extractors were used in the same semi-automatic pistol to produce samples of known and unknown cartridge casings. A group of firearm and toolmark examiners were given test sets of these cartridge casings to attempt to make the correct associations between the known and unknown casings. Each examiner was to receive 12 unknown casings in addition to standards for the ten consecutively manufactured extractors, with each known having at least one unknown associated with it. This study showed that when a proper scientific approach is applied the correct identifications could be made and the extractors could be distinguished from each other regardless of the fact that they were consecutively manufactured.

Introduction

The ability of a firearm and toolmark examiner to identify the origin of a toolmark has been established and accepted in the courts for some time. There have also been a number of empirical studies that have reflected on the discipline's ability to reach this conclusion. The ability to make an association between a known standard and a toolmark of unknown origin is based on the characteristics that the toolmark exhibits.

This study focused on the ability of the field of firearms and toolmark identification to be able to individualize a toolmark. Could extractor marks on cartridge casings be associated with the extractor of origin? When consecutively manufactured extractors were used to produce the extractor marks on known standards and questioned casings, could examiners make the correct associations between the extractors? It was not known if the consecutive manufacture process would lead to characteristics that would make identification impossible. This research will attempt to answer this question, and to determine to what extent the characteristics are individual.

Previous Research

Sub-class characteristics are produced incidental to manufacture and relate to a smaller group. An examiner must be careful not to confuse sub-class characteristics with individual characteristics. In a study conducted by Burd and Gilmore of mass-produced screwdrivers, they showed that the production methods used to make large numbers of tools often result in repetitive structure details being left on the tool surfaces, and their structure can resemble individual characteristics when they are in fact sub-class characteristics [1].

In a study of consecutively manufactured tongue-and-groove pliers conducted by Cassidy, he stated that tool surfaces would be individualistic if grinding, broaching or milling produces those surfaces. Cassidy also stated that consecutive manufacture could leave characteristics that might be accepted as individual [2].

Hall conducted research using four button-swaged Shilen rifle barrels with polygonal rifling. Four barrels were obtained and a series of bullets fired for comparison. It was believed that the bullets that showed the most agreement would be the ones fired in consecutive order from consecutive barrels. He concluded that there was not enough agreement in the markings on bullets fired from two consecutively manufactured barrels to introduce the risk of false identification [3].

A study of consecutively manufactured chisels was conducted using four sets of three consecutively manufactured (consecutively finished) chisels. With these particular tools, sub-class characteristics were observed prior to the actual finishing step, which is a grinding operation. Any grinding operation produces highly individual markings due to the random nature of the tool movement along with the fact that the tool surface is ever changing. Consecutively finished tools do not produce toolmarks with matching features [4].

One of the more familiar studies concerned itself with ten consecutively rifled Ruger barrels. A series of tests were completed using bullets fired from these consecutively rifled

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barrels. Initially, thirty firearm and toolmark examiners examined these bullets and were able to make the correct associations between known standards and unknowns. There were no misidentifications made. This study proved that the individual characteristics could be differentiated between consecutively rifled barrels [5].

Tool working surfaces can change over time. The extractor hook is no different in this respect than any other tool. An earlier study examined 5,000 consecutively fired bullets and cartridge cases from a .45 caliber M1911A1 semi-automatic pistol. This study showed that the number one cartridge casing was identifiable to the number 5,000 cartridge casing. There was some change in the unique surface contours of the extractor hook over the 5,000 test fires, but it was still identifiable. The reproducibility of extractor marks was established [6].

Materials and Methods

A number of the larger firearm manufacturers were contacted in regard to their ability and willingness to provide the ten consecutively manufactured extractors necessary for this study. Many of these manufacturers were initially eager and willing to provide the extractors, however, after consulting with their respective production managers and engineers, this task was harder than it originally appeared. For all of the major manufacturers contacted who at first agreed to help, the process of manufacturing ten extractors and following them through the entire manufacturing process was too expensive and manpower intensive. This would necessitate dedicating a machine operator to follow the extractors and keep them in correct order through the milling steps and then through the separate finishing steps, such as bluing and heat-treating. Ultimately, none of the major firearm manufacturers could be of assistance in the actual production of the ten consecutively manufactured extractors. Many manufacturers were willing to, and some actually did send ten extractors from the same manufactured lot. These were not consecutively manufactured. They were, however, helpful in providing insight into the mechanics of their operation and specifically into the production steps of extractor manufacture.

The focus on extractor manufacturing was switched from the larger firearm manufacturers to smaller firearm manufacturers. While this was a different approach to the problem of obtaining consecutively manufactured extractors the end results were similar. These small firearm manufacturers for the most part rely on vendors for the smaller components they use in the production of their firearms, such as extractors. By using no more of a criteria than their proximity to Albany, N.Y., a small company, Caspian Arms, Ltd., located in Hardwick, Vermont was contacted.

Caspian Arms Ltd. is a manufacturer of custom components for Model 1911 type pistols. They also manufacture custom slides for Glock pistols [7]. Craftsmen on manual machines do much of the manufacturing, although they do have the latest computer numerical controlled machines (CNC). Caspian Arms Ltd. had its beginning in the early 1980's as a contract producer of Model 1911 pistol components for such other firearm manufacturers as Randall and Detonics, among others. The company was originally named Foster Industries after the founder, Calvert Foster, Sr. Foster Industries was incorporated in 1983 and Caspian Arms Ltd was created as a sub-division of Foster Industries. Caspian Arms Ltd is the label Calvin Foster Sr. gave his own Model 1911 components and slides produced for individuals as well as for other manufacturers of the Model 1911 type pistol [8].

The intent and purpose of the research project was presented and, like other manufacturers, Caspian Arms Ltd. was willing to participate. Before they could commit they first had to consult with the machinist operating the milling machines. Caspian Arms Ltd ultimately responded and indicated that it would in fact be possible to produce ten consecutively manufactured extractors in their facility.

Caspian Arms Ltd's production of extractors is not a regularly scheduled event. Extractors are produced in lots at varying intervals when needed. When the level of extractors on hand drops below a certain level, extractor production is resumed to replenish their stock. They maintain a stock of partially completed extractors and finish them in lots as needed [9]. Since the production schedule was varied it was not possible to arrange to be present to observe the manufacture of the extractors to confirm they were, in fact, consecutive. Caspian Arms Ltd provided certification stating that the extractors were produced in consecutive order.

The extractor begins as bar stock received from an outside vendor (see Figure 1). The bar stock is made of 4340 material. This 4340 material is high carbon steel. This material is used since it has what is referred to as a good memory. This memory allows the material to function as a spring while retaining its strength. It has a target Rockwell hardness of 50 that allows for good spring tension without the metal being too brittle [10].

The first operation that the bar stock undergoes is a milling process on a horizontal milling machine (see Figure 2). This type of milling machine performs the first two cutting

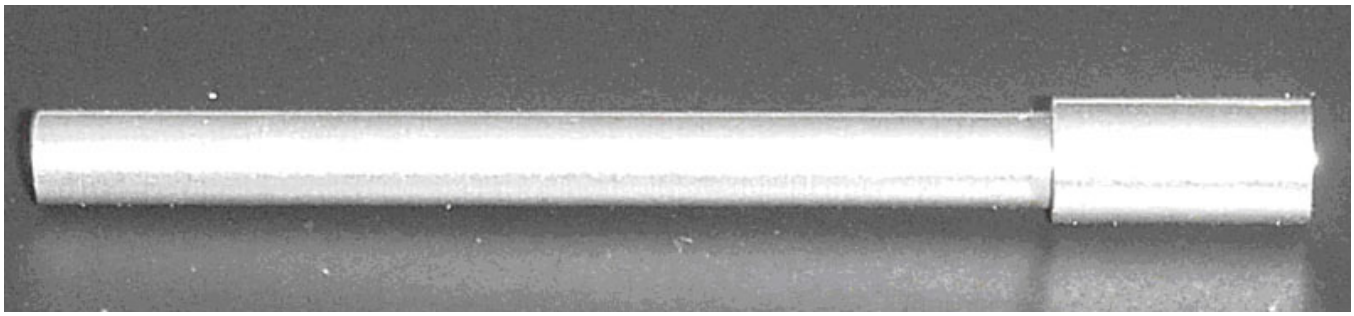

Figure 1: Barstock as received from vendor

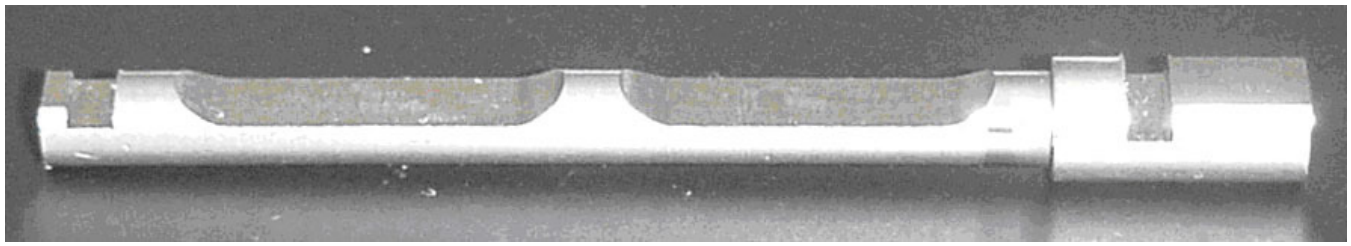

Figure 2: Barstock after first horizontal cut

operations on the bar stock. The bar stock is placed on the worktable and the interlocking side milling cutters perform the first cut which includes the extractor hook. The cutting edge of the interlocking side-milling cutter on the horizontal milling machine used at Caspian Arms cuts approximately 1,000 to 1,500 extractors before the cutting surfaces need to be retooled [11]. This is the only time a tool touches the hook of the extractor. Most of the individual characteristics that the hook possesses are formed in this first step. The rest of the individual characteristics are formed incidental to the actual manufacture, primarily by the extractors striking each other, as they are stored in lots of 500.

The partially formed extractor is removed from the worktable and turned over. The horizontal milling machine will now perform the second cutting operation, which forms the reverse side of the extractor (see Figure 3). Once again, the bar stock is held in place on the worktable as the interlocking side milling cutters remove material. Both sides of the extractor have now been milled down.

The next step would be to complete the milling operations on the vertical milling machine. The vertical milling machine performs five cutting operations, all of which are merely trimming functions and do not affect or touch the extractor hook. These milling operations produce burrs, which are deposits of the cut metal that are left behind by the cutting tool when it leaves the work piece. These burrs are removed by hand using de-burring knives. A de-burring knife is a hardened steel hand tool used for scrapping burrs off of newly machined areas [12]. This is a process that is used by other manufacturers as well [13].

Once the extractors are de-burred they are sent off site for heat-treating. This is necessary to strengthen the material. Without heat treating the metal would not withstand the forces it is subjected to during the extraction process and eventually bend or warp. The heat-treating allows the metal to be case hardened, which means the outer surface is harder than the interior which allows it to retain its flexibility. After the extractors are returned from heat treating they go through

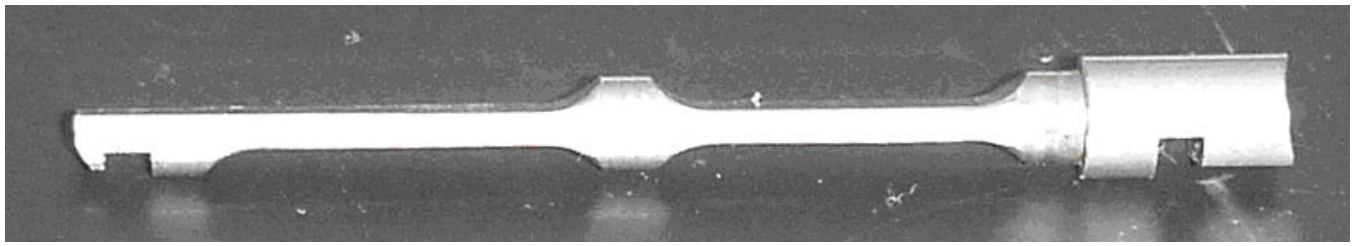

Figure 3: Barstock after second horizontal cut

an operation that utilizes both a tumbling process as well as a glass blasting process. The extractors are placed inside a rotating wire mesh drum that is blasted with glass beads as the drum rotates. This is the final step before the extractors are sent to another vendor for finishing. A black oxide finish is applied to protect the metal. Caspian Arms, Ltd. also produces stainless steel extractors.

The firearm chosen for this study was a Colt, Model 1911A1, .45 ACP caliber pistol, serial number C139999, determined to have been manufactured on November 24, 1925 [14]. It was examined, completely disassembled, cleaned, reassembled and determined to be in good working order prior to use in this study (see Figure 4).

Figure 4: Colt Model 1911A1

Caspian Arms Ltd. provided ten consecutively manufactured extractors which they stamped 0 through 9, 0 being the first extractor of the ten produced. These were maintained in consecutive order throughout the machining phases, and all have the black oxide finish.

The pistol was again field stripped and the original extractor removed and replaced with the first extractor of the ten consecutively manufactured extractors, number 0. The pistol was then re-assembled. A single 45 ACP dummy cartridge was loaded into the magazine and the magazine was then inserted into the pistol. The dummy cartridge was then loaded into the chamber in the normal fashion by working the action. The action was worked again to extract and eject the dummy cartridge. The pistol was then field stripped again, and extractor #0 was removed and replaced with extractor #1. The pistol was re-assembled and loaded with the 45 ACP dummy cartridge. This process was repeated for each of the ten consecutive extractors. Each extractor was assembled into the test pistol to ensure that it did fit. The dummy cartridge was worked through the pistol to ensure the extractor functioned as designed.

Once the pistol was selected and tested, along with the consecutive extractors, the remaining item to be evaluated was the ammunition. A survey of the ammunition reference collection maintained by the NYSP Firearms Identification Unit revealed a variety of ammunition available in 45 ACP caliber. The main area of concern for this study was the type of material used for the cartridge casing. The survey revealed a number of brands available which used brass, nickeled brass or aluminum for the casings. No consideration was given to the type or weight of the projectile since only the casing would be recovered. Relative samples of the 45 ACP caliber cartridges in the reference collection were chosen for testing. These included 45 ACP caliber cartridges with brass cases from Remington, Winchester, S&W, Hornady and Hansen Cartridge Co., nickel cases from Federal and Remington, and aluminum cases from CCI.

The ammunition was test fired in the selected pistol chosen for this study using the original extractor. Test firing was conducted in the indoor range at the NYSP Forensic Investigation Center. Two cartridges of each of the different brands of the available 45 ACP ammunition were fired and the casings recovered. These casing were then subjected to a microscopic examination. This examination was to evaluate the quality of the extractor marks in general, and more specifically, to examine if the type of material the casing were composed of affected the quality of the extractor marks. The final step was to compare the casings of the different materials to each other. It was established that the extractor marks were identifiable regardless of the type of material used in the cartridge casings.

It was noted that the markings on the aluminum casings were not as well defined as those markings on the brass and nickel casings. The brass and nickel casings seemed to be very similar in the quality of the extractor marks. These marks seemed to be very well defined. These casings were examined by two firearm and tool mark examiners and the consensus was that either the brass or nickel casings would be acceptable for this project. This is not to say that the extractor markings on the aluminum casings were unidentifiable. They were identifiable, however, the extractor marks on the brass and nickel casings were, as stated, better defined.

During the microscopic examination of the extractor marks it was discovered that there were striated markings in the

general area of the extractor marks that were not attributed to the extractor itself. It was discovered that these striated marks were originating from the pistol's magazine. Specifically, the magazine lips were leaving striated marks on the rim of the casings. These striated marks are made when the cartridge is first loaded into the magazine, and again when the cartridge is stripped from the magazine during the feeding and loading cycle of the pistol. It was observed that the right magazine lip and the extractor both mark the casing in the same area. These marks are not always overlapping. There is some rotation of the cartridge as it is loaded into the magazine. There is also some rotation of the cartridge as it is stripped from the magazine and loaded into the chamber. There is still more rotation, however slight, as the cartridge case is extracted from the chamber prior to ejection. There were a few instances where these marks did overlap and it made identifying the extractor mark difficult.

Ten additional test fires were conducted. Five cartridges were loaded in to the pistol in the traditional manner, that is, by loading the magazine and inserting it into the pistol. Five other cartridges were loaded into the chamber by hand through the ejection port. These ten cartridges were test fired and the casings collected for microscopic examination.

As expected, the cartridge casings that were hand loaded through the ejection port possessed extractor marks that were easily discernible as opposed to those cartridge casings that were loaded by way of the magazine. The hand loaded cartridge casings did not have the striated markings from the magazine lip interfering with the extractor marks. Since the focus of this study was strictly the identification of extractor marks it was decided that the cartridges for this test would be hand loaded through the ejection port into the chamber. Doing this would allow the examiners who participated in this study to focus only on the extractor marks. The same firearm was to be used throughout the test firing with the only difference being the replacement of the extractor. The only questioned mark would be the extractor mark, without interference from the magazine lips.

As stated earlier the type and caliber of firearm used for this study was chosen by default. The consecutive extractors obtained for this project dictated what type and caliber firearm would be used. The ammunition for this study was also chosen by default. After the aluminum cartridge case was eliminated as being less desirable than either brass or nickel, the decision came down to how much money was available in the budget for this project. That factor would be the most influential in determining the type of ammunition used. The present fiscal climate required that the least expensive ammunition be purchased for this study. It was determined that both the brass casings and the nickel casings marked equally well. With this information a number of retail ammunition dealers were contacted and a basic survey was conducted to determine the available .45 ACP caliber ammunition currently in stock and the cost of a complete case. The deciding factor was cost and ultimately the least expensive ammunition was chosen which was Speer Lawman .45 Auto 230 grain, full metal jacket. This brass case ammunition was purchased from a local sporting goods store in the Albany area.

Each box of fifty cartridges in the case was examined to confirm that they were all from the same manufactured lot. Each box was marked with a bar code and three sets of numbers. Since it was unclear which set of numbers represented the manufacturer's lot number, Speer was contacted. It was confirmed that the lot number was E30H21 and all twenty boxes in the case were from the same manufacturer's lot [15].

The Colt pistol was field stripped and the original extractor removed and replaced with consecutive extractor number 0. It was then test fired in the indoor range. Two Speer Lawman .45 Auto caliber cartridges were fired. Each cartridge was loaded into the chamber by hand through the ejection port. After the cartridges were fired the casings were retrieved and immediately marked " #0 ".

The pistol was then field stripped and extractor #0 removed and replaced with extractor #1. The pistol was again test fired with two cartridges from the purchased case of Speer ammunition. The casings were retrieved and, again, immediately marked accordingly. This procedure was repeated for each of the consecutively numbered extractors until two expended casings for each extractor were obtained and correctly marked with the corresponding extractor number.

These casings were then microscopically examined to determine the quality of the extractor marks as well as to see if the consecutively manufactured extractors possessed enough individual characteristics to distinguish it from the next consecutive extractor.

Each casing was first compared to the other casing from the same extractor set. Casing number 0 was compared to casing number 0, casing number 1 compared to casing number 1, and so on throughout the entire set. Every pair of casings was identified to each other by the extractor marks. Once it was determined that each casing from the same extractor could be identified to the other, they were then compared to the set of casings from the next consecutive extractor. The casings from extractor number 0, after being compared to each other, were then compared with casings from extractor number 1. After it was established that differences existed that could distinguish

extractor number 0 from extractor number 1, then the casings from extractor number 1 were compared to the casing from extractor number 2. This process was continued until all sets of casings were compared to the next extractor in numerical order. It was demonstrated that there were enough individual characteristics to distinguish between the consecutively manufactured extractors.

Since these were known casings being compared to known casings some prejudice might have existed. Further comparisons were conducted. The sets of known casings were divided into two groups, each group containing one casing from each of the consecutively manufactured extractors. A casing from each set was randomly selected for comparison to each other. This was continued until all the casings were correctly identified to the other from the same extractor set.

This proved to be an interesting exercise. In addition to the fact that the consecutively manufactured extractors possess enough individual characteristics for the correct identifications to be made, it was noted that sub-class characteristics carried over from extractor to extractor. This sub-class carry over did not preclude the correct identifications from being made. While it certainly added to the difficulty, enough individual characteristics did exist for the correct identification to be made. This sub-class carryover was not unexpected considering the manufacturing process that the extractors undergo. An examiner must, of course, take care to not confuse sub-class characteristics with individual characteristics (see Figures 5-7).

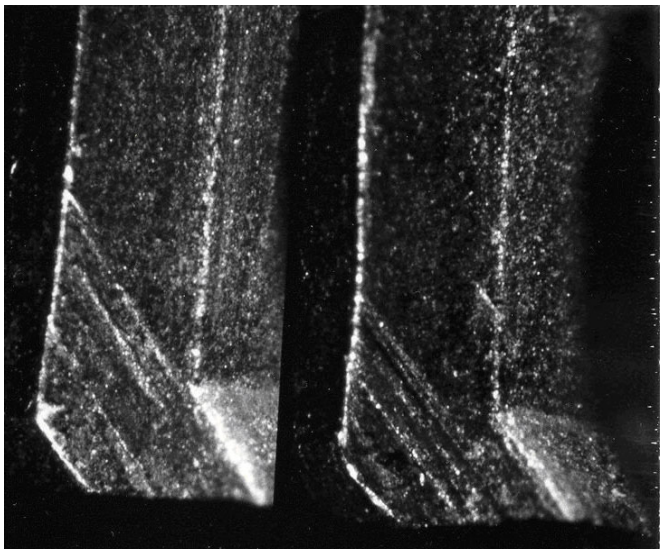

Figure 5: Example of subclass characteristics
Extractor 3 (Left) Extractor 1 (right)

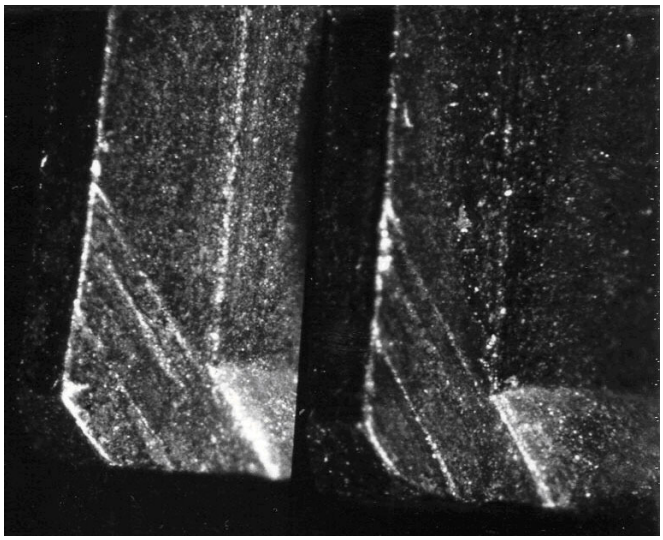

Figure 6: Example of subclass characteristics
Extractor 3 (Left) Extractor 4 (right)

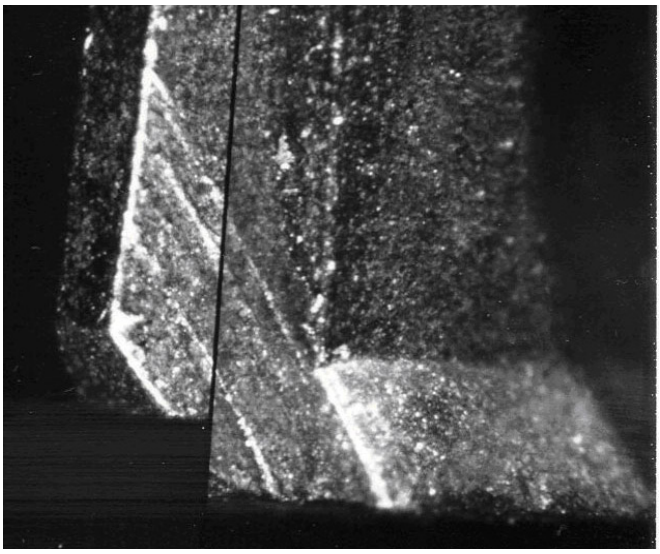

Figure 7: Comparison of subclass characteristics
Extractor 3 (Left) Extractor 4 (right)

It was now established that this project could move forward. The extractors were examined and tested in the selected pistol; the ammunition was tested and selected as well. The casings from the test fires using the consecutively manufactured extractors were examined for the quality and reproducibility of marks that were individual to that particular extractor.

The Colt Model 1911A1 pistol was once again field stripped and extractor number 9 was removed. Extractor number 9 was replaced with consecutive extractor number 0. The pistol was then re-assembled. Seventy-five new 45 Auto Speer Lawman cartridges were placed in a plastic bag that was

marked "extractor #0". These cartridges were brought down to the indoor range for test firing in the Colt semi-automatic pistol.

Prior to conducting the test firing of the project ammunition, the indoor range was cleaned to ensure there were no casings from previous test firing lying around. This was to prevent casings from unknown origin being mistakenly included in this project.

Each cartridge was loaded by hand into the chamber of the pistol to avoid the placement of any striated marks on the casing by the magazine. After all seventy-five cartridges were loaded and fired, the casings were retrieved, counted and placed in the plastic bag marked "extractor #0". This bag was then heat sealed to prevent any accidental mixing of the casings. A strict count was maintained in order to assure no casings were left in the range that could later be picked up and mislabeled. The heat sealed bags would remain sealed until the time that the individual casings could have the extractor number scribed on them.

The Colt pistol was again field stripped and assembled with consecutive extractor number 1. Seventy-five more cartridges were carefully counted out and fired on the indoor range. These casings were recovered, carefully counted, and sealed in another plastic bag marked "extractor #1". This process was repeated for each of the consecutively manufactured extractors. The cartridge casings were all accounted for.

The Colt pistol was disassembled and cleaned. After cleaning and lubricating the pistol it was re-assembled with the original extractor and returned to the firearm reference collection. No misfires or jams were experienced in the test firing of the seven hundred and fifty test specimens as well as during the ammunition evaluation phase. The Colt Model 1911A1 functioned flawlessly.

As previously stated, the seventy-five casings for each numbered extractor were heat sealed in plastic bags. The original design was to have enough casings to produce twenty test sets to send to different examiners for examination and comparison. In order to prepare these casings for assembly into test sets they first had to be scribed with identifying marks, for both the known casings and those that would be presented as unknown.

Before this could be done the packaging materials for the test sets had to be assembled. Small coin envelopes were obtained for both the known and unknown casings. Larger padded mailing envelopes were obtained and labels printed for mailing. An instruction sheet was drafted and printed, as well as an answer sheet. The coin envelopes were labeled for extractor number 0 as such:

KNOWN
Two (2) Cartridge Casings
Consecutive Extractor #0.

This was repeated for each of the numbered extractors. When the labeling for the known envelopes was completed, the casings were then scribed with the extractor number. The bag marked "extractor number 0" was opened and forty casings were counted out. The bag was then resealed. These forty casings were then each scribed "#0". This process was repeated for each plastic bag containing the casings from the numbered extractors. When this step was finished there were ten sealed, marked plastic bags containing unmarked casings from each of the numbered extractors. There were also, for each numbered extractor, twenty labeled envelopes, each containing two marked casings, for a total of two hundred envelopes and four hundred marked casings.

The casings that would be labeled unknown had to be marked for the test. These were given alpha character designations. With the assistance of two non-firearm employees of the Forensic Investigation Center, numbers were assigned for the recipients of the test sets. These were assigned by a random drawing. Once an order of the test sets were established, letters were randomly drawn for each extractor. When this was completed, another set of random letters were drawn and randomly assigned to them.

Each bag of unknown casings were again opened one at a time so that no more than one bag was unsealed at any moment. The casings remaining in each bag were then divided into two groups. The alpha characters randomly assigned to the casings were then scribed on the casings. Eight casings received one letter; the other seven casings received the second letter. These casings were then sealed in coin envelopes that were marked:

QUESTIONED
One (1) Expended Casing
Marked "A".

Each envelope was labeled with the correct alpha character that was scribed on the casings. For each extractor there now existed twenty envelopes containing two known casings for a total of forty known casings, and thirty-five envelopes containing a single unknown casing for each extractor, for a total of two hundred envelopes with 400 known, and 350 envelopes containing 350 unknowns.

Once the test sets were completed a pre-test was conducted to determine if problems existed in either the instruction sheet, the answer set or in the construction of the actual test. The instruction sheet and answer sheet were reviewed by two firearm examiners with an average of ten years experience in a laboratory accredited by the American Society of Crime Laboratory Directors/ Laboratory Accreditation Board (ASCLD/LAB) in the field of firearm and tool mark examinations. Samples of the known and unknown casings were distributed to theses examiners for examination and identification. The pre-test was a limited test designed as such due to the time constraints of this project. While both examiners did not examine a complete test set, a relative sample was examined and the correct identifications made. Each examiner was given more unknowns than knowns to ensure that all the casings given to the examiners were examined.

Needed for this study were firearm and toolmark examiners who were not only willing to participate, but also whose laboratories would allow them to take the time needed to complete the examinations. After locating examiners willing to participate, they were each mailed an instruction sheet, answer sheet and test set. These were mailed in padded mailers to help protect the casings from damage. Each test set contained twenty known casings marked with the extractor number, and twelve unknowns, each marked with the randomly assigned alpha character. They simply had to make the identification and indicate such by circling the corresponding letter on the answer sheet. It was not expected of the examiners to take notes or photographs, other than that which enabled them to complete this exercise, however, most approached this as case work in regards to the documentation of their identifications.

The firearm and toolmark examiners who participated in this study work in laboratories on the federal, state and local levels. Local includes both city and county laboratories. Some of the participants are retired from the field of firearm and toolmark identification but remain active as private consultants. The laboratories also differ in that most provide their services without charge to the criminal justice community while others are fee-based. Some of these laboratories were accredited by such national accreditation boards as ASCLD/LAB, some laboratories are in the process of being inspected by ASCLD/LAB for accreditation, while others remain unaffiliated with any accreditation board.

The level of experience possessed by these examiners was quite varied. While attempts were made to include only experienced firearm examiners who worked in accredited laboratories, modifications were made as the project progressed. The most experienced examiner has 40 years of experience; the least experienced examiner was an entry-level examiner with one year of training. The median amount of experience by this group was 18 years.

Results and Discussion

Some problems were discovered during the testing phase. These problems were not encountered during the pre-test phase. These problems ranged from the construction of the test set to the wording on the instruction sheet.

The first problem encountered was on test set number 4. The associated answer sheet was returned with ten identifications rather than the expected twelve. There was no indication of any inconclusive results on the answer sheet. When the submitting examiner was contacted it was explained that the examiner believed only ten identifications were requested. A review of the instruction sheet indicated that there was at least one unknown for each known, meaning that some knowns may have more than one unknown associated with it. The examiner understood this to mean there was only one unknown for each known and that the remaining two casings were from extractors other than the consecutively manufactured ones.

The answer sheet was returned to the examiner without the examiner knowing if the ten identifications submitted were correct. The examiner was asked to include the remaining two casings on the answer sheet, if in fact identifications could be made. The examiner completed the remaining examinations and re-submitted the answer sheet reflecting twelve identifications. These two additional identifications, as well as the first ten, were all correct.

This misunderstanding of the instruction sheet was considered an isolated incident that would have no bearing on the results of this project. There was, however, another examiner who also misinterpreted the instruction sheet, with very different results.

Answer sheet number 7 was returned with three misidentifications recorded. Extractor #0 had a letter circled on the answer sheet that indicated the examiner had made an identification. There were two identifications recorded for extractor #7. The answer sheet had some notations on it concerning extractor #7 indicating that this extractor would get more tests. This apparently meant that if this were casework more tests casings would be needed since the ones supplied were difficult to identify.

This examiner at first indicated that they had trouble matching two unknowns. The examiner was then able to make an

identification between these casings, but was unable to identify them to any known extractor. It is believed that they should have been marked as inconclusive if they could not be either identified to an extractor, or eliminated. This is where the wording of the instruction sheet seemed to confuse the examiner. The examiner stated that they understood the directions to mean there was only one unknown for each known. They also stated that they felt the test had a built in error due to the wording of the instruction sheet.

If the last two remaining cartridge casings could not be identified or excluded they should have been marked inconclusive. An inconclusive response would not have been considered a wrong answer since inconclusive is a valid conclusion. In this study, as well as in casework, the extractor does not always leave ideal marks for identification. While some of the extractor marks were less than ideal, they represent what an examiner faces in actual casework, so no attempt was made to exclude casings with less than perfect extractor marks.

The examiner stated that they were, after some time, able to identify the last remaining cartridge casings to each other. According to their understanding of the instructions, they must then be associated with the last remaining known. The problem with this reasoning is in assuming that the other associations were all correct. This was not the case. There was one misidentification. The two remaining unknowns, while correctly identified to each other, were misidentified to the wrong extractor. Even if the two misidentifications that were made to the same extractor were excluded due to the instruction sheet and what the examiner considered a built in error, there still remains a misidentification. The standards used for casework were not applied to the test.

The known cartridge casings in this test for extractor #0 and #7 were compared to the known cartridge casings #0 and #7 of another test set. This comparison was conducted by one examiner and confirmed by a second examiner. This confirms that the test set standards were the correct ones and not mistakenly mixed with cartridge casings from another extractor and mis-labeled.

The issue concerning the instruction sheet was considered an isolated incident as previously stated. It was treated as an oversight by the responding examiner. When the issue was raised by a second examiner the matter warranted a closer look. No problems were detected during the drafting stages for the instruction sheet or the answer key, or during the pre-test phase. Other firearm examiners reviewed the instruction sheet and understood what the objectives were and how they were to be achieved. No potential problems were detected. This might be, however, due to the fact that they may have been too familiar with the study and may have unconsciously overlooked any confusing wording since they knew what was expected. If this study or a similar study were to be undertaken in the future a more explicit instruction sheet would be provided. Persons not close to the study would also review this.

A second problem was discovered when answer sheet number 6 was returned. Answer sheet number 6, like answer sheet number 4, only reflected ten identifications and did not have any notation of inconclusive results. When the examiner was contacted it was discovered that the examiner only received ten unknown casings. An error in assembly resulted in the test set being forwarded with ten unknown casings instead of twelve unknown casings. The correct identification of the ten unknown casings was made. It raises one question, however, concerning the last, or tenth identification. The test sets were intentionally constructed to have more unknown casings than known casings. In a test designed like this one, each known has a matching unknown. By including more unknown casings than known casings an examiner would have to look at every casing to determine if identifications could be made. By including the same number of unknowns as knowns, and indicating that all knowns had a match, then the last casing could be correctly assigned by the process of elimination without having to examine it, providing, of course, that the previous nine identifications were, in fact, correct.

This does not question the results of the examination of the casings by this examiner. All the correct identifications were made. A sound practice is to examine all the casings in order to be confident of the results and identifications, and there is no indication or reason to suspect that this was not the case.

A total of fifteen answer sheets were returned. There were twelve answer sheets that contained twelve out of twelve correct identifications. There was one answer sheet that contained ten correct identifications out of a possible ten. This was the one test set that was sent out with only ten unknowns rather than the planned twelve. One answer sheet was returned with 9 correct identifications out of a possible twelve. The last answer sheet had eleven correct identifications with one inconclusive. There were a total of 175 correct identifications out of a possible 178 correct identifications, for an accuracy rate of 98.3 %. This study has, currently, an error rate of 1.7%. It is anticipated that the test sets in circulation will be distributed to other examiners for training or testing purposes. Additional responses are expected and these will be included at that time in the totals. This error rate will be adjusted appropriately as the responses are compiled.

The answer sheet with the incorrect identifications (nine out of twelve) was at first considered for exclusion. Since the responding examiner misunderstood the directions it was contemplated that the results should not be considered. It was also considered that the examiner made nine correct identifications and at least two of the three misidentifications were the result of deviating from standard practice used in casework. After some consideration the answer sheet was included. An exclusion, it was felt, would appear as an attempt to slant the study in a favorable direction and not be truly representative of the results.

Prior to preparing the test packages the cartridge casings were examined microscopically to determine the quality of the extractor marks. There was a great deal of variations in the marks, not only between the different extractors but also in the casings from the same extractors. Most of the marks were fairly good striated marks with little distortion. Some did display a good deal of wavy striation and curvature. It was expected that some examiners might request additional samples of the known casings. No examiner requested additional known standards to complete their examinations.

It was also expected that there would be a number of inconclusive responses. Instead, there was only one. This inconclusive answer was included in the correct response total. It is not known why the examiner came to an inconclusive conclusion. It is possible that there might not have been enough individual detail to identify or eliminate. Since an inconclusive response is not an incorrect response it was totaled with the correct response and figured into the error rate as such.

The error rate for this project compares favorably to the most recent error rate established for firearm and toolmark examiners by Collaborative Testing Services (CTS). CTS provide a wide range of proficiency test to the forensic community, as well as for industrial use, which include firearm and toolmark examinations. The most recent data available from their website lists an error rate of 0% on the latest firearm proficiency test. The responding examiners made the correct associations between expended cartridge casings. The toolmark proficiency test had an error rate of 2%. (16) While they did have some incorrect responses, this extremely low error rate demonstrates the quality of examinations being performed in the field of firearm and toolmark examination.

Conclusions

This project started with the fundamental question of whether or not extractor marks originating from consecutively manufactured extractors could be correctly associated with the extractor of origin. This research also attempted to provide insight into the manufacturing process of extractors, and the effect the manufacturing process has on the individualization of both the tool working surface and the toolmark.

The tool making process was explored and it was demonstrated that the individual characteristics originate in the production steps. It is the machining process, as well as the use, abuse and corrosion of manufactured items that lend themselves to the individualization of toolmarks. By creating unique surface contours on the manufactured piece, the item's working surfaces can produce unique toolmarks. This is the basis for an identification. How an examiner is able to articulate this in a court of law is crucial to the prosecution of cases. Empirical studies, personal casework, and training are the basis for an examiner to reach conclusions from their examinations. By comparing known standards to each other an examiner can learn what sort of agreement in found in a known match. By comparing toolmarks of different origins an examiner can also learn the level of agreement that can be found in toolmarks of different origins. This also provides an understanding that there is some level of agreement in marks made by different tools, as well as differences in two marks made by the same tool.

Ten consecutively manufactured extractors were obtained and used to produce known standards as well as questioned cartridge casings. Firearm and toolmark examiners from around the country were given test sets to determine if they could make the correct associations between the known standards and the questioned cartridge casing. The results prove that not only can the correct associations be made, but also that there exists enough differences between consecutively manufactured extractors that an incorrect identification was not made.

The extractors used for this research also demonstrated very pronounced sub-class characteristics. Sub-class characteristics relegate the extractors to a smaller group, which can also be misleading. If an examiner is not careful, sub-class characteristics can be mistaken for individual characteristics and lead to an improper conclusion.

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Editor's Note

Since the time that that the original research was performed, there have been several more participants. The total number of participants currently now stands at 22. From these participaants a total of 259 correct answers out of a possible 262 were produced, which changes the error rate from original work from 1.7% to 1.2%.

For those who have an interest in participating, the author would like to make it known that a limited supply of tests are still available.

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