NanoTag™ Markings From Another Perspective

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ABSTRACT

The science of Forensic Firearm and Toolmark Examination relies on the use of highly trained and skilled individuals to identify & compare accidental markings left on expended ammunition components. To circumvent the need for these individuals, it has long been suggested to rely on manufacturer-generated unique characteristics that would be transferred onto the expended components. By doing this, the examination of an expended ammunition component could lead one back to the original purchaser of the firearm, without the need to recover the actual firearm. This would offer law enforcement a tool that current instrumental tools, designed to examine accidental markings, seem unable to deliver. Current changes in technology have now made it possible for manufacturer-generated unique identifiers to be placed on firearm components. The sole source vendor of this technology, NanoTag™, promises a method that is indelible, individual, 100% reliable, and cost effective. The question that must be asked is: Is an age-old problem about to be resolved with a new solution, or will all the challenges that have required the extensive training and experience of examiners, still prove an obstacle to success?

Forensic Firearm and Toolmark Examiners have long possessed the knowledge and instrumentation to routinely perform sole source identifications of expended ammunition components back to the weapons that had fired them. They also are capable of comparing expended components to determine whether those components were fired in, or from, a common weapon without ever seeing that actual weapon. Currently, the manufacture and sale of firearms is one of the most regulated industries in the country. Every firearm manufactured must be permanently marked with a unique identifier that is traceable back to the manufacturer and the first point of sale to the public. What law enforcement lacks is the ability to sole source identify an expended ammunition component back to that readily traceable firearm that fired it, without the recovery of the firearm itself. Regionally implemented extensions of the currently utilized ballistic imaging systems have so far been unable to accomplish this task. The current search engines being used to examine the class and individual characteristics found on expended bullets and cartridge cases do not appear to be sufficiently refined to deal with extremely large databases.

The sole source vendor of a new technology, NanoTag™, proposes that the firearm industry implement its technology to place a serial number on components of the firearm that come in contact with the cartridge during firing, thereby transferring the weapon's identity onto the expended components that could be recovered at a crime scene. This vendor suggests that NanoTag™ markings will be readily identifiable at the crime scene, with 100% reliability, with little to no training of the analyst needed, and yet remain easily affordable. While the proposed concept seems too simple to fail, the experience of this examiner suggested further examination and testing would be necessary before the firearms industry embraces the proposed solution.

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The NanoTag™ technology (marketed by Hitachi Digital Imaging, formerly NanoVia) uses an instrument/machine capable of laser micro drilling a series of connected blind holes. These instruments are capable of very precisely removing materials, such as metal, in extremely uniform and predictable patterns. NanoTag™ technology, which is currently being used to combat microchip counterfeiting, is proposing the use of their technology to place micro serial numbers on various firearm parts that come in contact with a cartridge during its discharge. The weapon's unique serial number would be transferred onto the expended cartridge case which, if recovered at a crime scene, would allow law enforcement to identify the weapon used without the need to recover it. This author elected to investigate three questions as part of a preliminary study:

- Would the markings be readily decipherable? (Essentially how reproducible would NanoTag™ markings be?)
- How resistant to wear would the NanoTag™ engraved firing pin be under normal use?
- How susceptible would the NanoTag™ engraved firing pin be to intentional defacement?

Presentations previously made addressing these questions seemed quite promising. The review of test-fired specimens from an unfinished research project by a member of the Rhode Island State Crime Laboratory seemed quite the opposite. His project involved the test firing of a Remington Arms Company .22 Long Rifle (LR) caliber semiautomatic rifle, model Nylon 66 that had been furnished with a NanoTag™ engraved firing pin (Figures 1,2).

This firearm was used to test fire a quantity of ammunition so as to assess how durable the NanoTag™ markings would be under normal use. A number of these test fires were forwarded to this researcher for examination (Figures 3,4). Microscopic examination and comparison of these expended cartridge cases revealed that the NanoTag™ markings were illegible as a result of the manner in which the firing pin comes into contact with the cartridge rim. The assumption is often made that the firing pin comes in contact with the cartridge a single time, forming a single impressed toolmark. In reality, it is often much more complex than that. During the firing of a cartridge, the firing pin will often strike the cartridge multiple times. Due to the manufacturing tolerances that exist, these additional impacts will overlap each other. Firearm examiners are used to dealing with this during comparisons, collecting multiple specimens to use during their comparisons. The examiner will then search for areas where only one layer of impressed toolmark is present and use that area to form his or her opinion. They see the change present over much of the area that forms the whole firing pin impression and realize that the non-reproducible toolmarks are the result of a varying circumstance. The NanoTag™ markings are being lost in this non-reproducible overlapping impact area.

In order for this research to progress, the Rhode Island Lab donated two NanoTag™ engraved firing pins designed to be used in the Colt .45 Auto caliber Government model 1911 semiautomatic pistol, and other similar models. This firearm was at one time the issue service weapon of the U.S. military. As a result, it has been made by a number of different manufacturers with parts designed to be fully interchangeable. It remains one of the most popular pistols made. This weapon utilizes a recoil operated semiautomatic action; as a result, there is a great deal of movement taking place during the firing of a cartridge. Each of the two firing pins was placed in a Colt .45 auto caliber semiautomatic pistol, customized Government Model. Each firing pin was test fired using Winchester and Federal brands of ammunition, to generate a total of ten cartridge cases for microscopic examination and comparison. Initial testing with one of the pins required an examination of all ten test fired casings to determine that the NanoTag™ serial number of this pin was "0H5K B4M3". The other pin was NanoTag™ engraved with many, much smaller, fonts. It was found to have "NanoTag™", the numerals 0 to 9, and the entire alphabet engraved into the pin's tip. The vast majority of this pin's characters were never visualized in the firing pin mark of any of the expended cartridge cases generated and examined.

Proponents of legislation currently proposed at a state level have suggested that it be required that the make, model, and serial number of the firearm all be placed on the firing pin's tip. Firing pin "0H5K B4M3" had significantly larger fonts than could be used to provide this quantity of information. This pin's characters had a height of approximately 0.008 inch, width of approximately 0.005 inch, and were raised a reported 25 microns, which is approximately 0.001 inch. The engraved area had a diameter of approximately 0.037 inch. By using eight characters in a similar manner, four letters and four numbers, over four billion combinations are possible. On the second firing pin, "NanoTag™…", forty-five characters

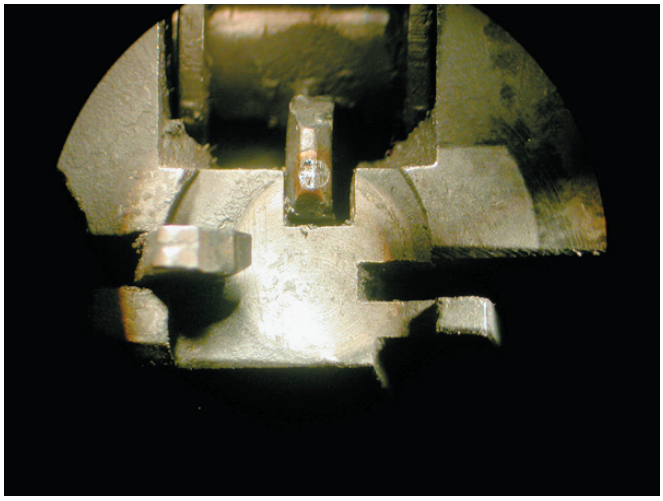

Figure 1: Breech face and firing pin from Remington Nylon 66 rifle equipped with a NanoTag™ engraved firing pin.

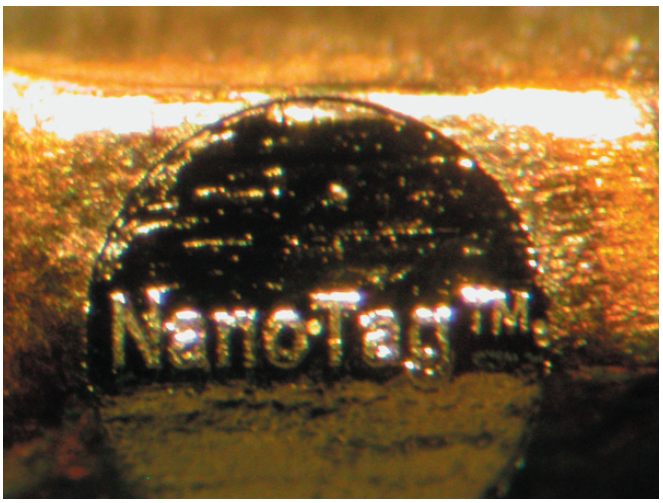

Figure 2: NanoTag™ engraved firing pin.

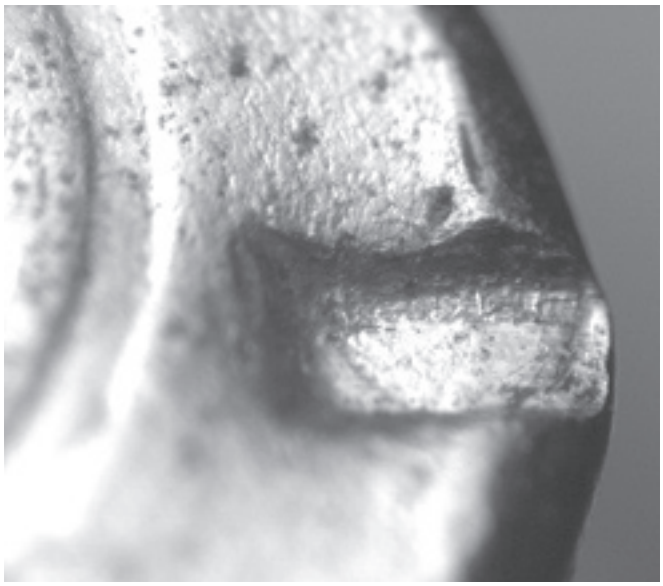

Figure 3: Previously generated test fire #25 (from Rhode Island original study).

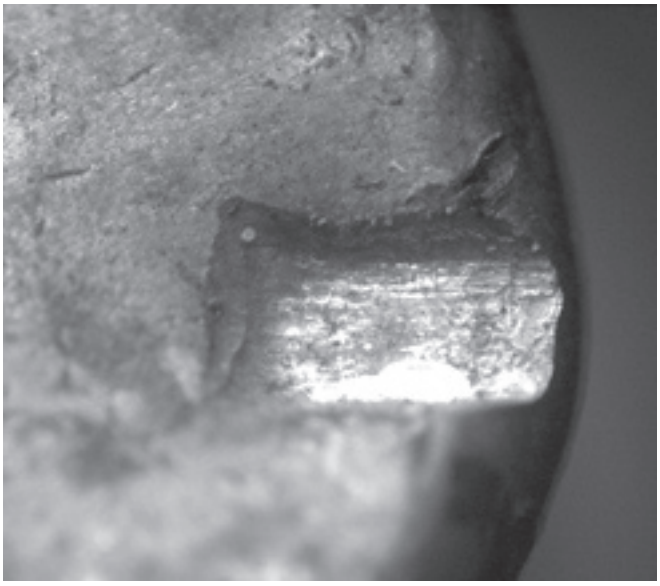

Figure 4: Previously generated test fire #125 (from Rhode Island original study).

were of three different heights, approximately 0.0017 inch, 0.0029 inch, and 0.0038 inch; the characters were raised uniformly but only a fraction of the height of the characters of the other firing pin. The NanoTag™ markings were very difficult to decipher on the second pin. As it was clear that the smaller size and height affected the quality of the transferred characters, all further testing was performed with only the NanoTag™ pin "0H5K B4M3".

The next series of tests involved placing the NanoTag™ firing pin "0H5K B4M3" into ten different Government Model pistols of different manufacturers and vintages. Firing pins are generally designed to be easily removable for cleaning or replacement. It takes about ten seconds to remove the firing pin from a Government Model pistol and about fifteen seconds to place it back into the weapon. The NanoTag™ firing pin was placed in each weapon and was test fired with ten Winchester brand .45 auto caliber cartridges. Each of these expended cartridge cases was microscopically examined to determine the legibility of the pin's serial number. If all eight of the characters were decipherable, that impression was graded "Satisfactory" (figure 7). If one or more of the characters was un-decipherable that impression was graded "Unsatisfactory" (Figures 6, 6a). The overall ratio of Satisfactory to Unsatisfactory impressions was 54 to 46. Once again, overlapping firing pin impacts often affected the quality of the impression. In addition, the presence of anvil marks (common to centerfire primed cartridges) and firing pin drag/wipe (found with many recoil-operated pistols of the Browning design) also caused a loss of information.

In order to evaluate how the NanoTag™ serial number present on the pin would be affected by normal use, one thousand rounds of Winchester brand .45 Auto caliber 230 gr. full metal jacket ammunition were fired. Rather than examine the expended cases, where the variable quality of the markings would interfere with making a determination, the firing pin was examined directly. After every one hundred cartridges were fired, the firing pin was removed from the firearm, microscopically examined, and its current condition was documented by photomicrographs. After one thousand rounds were fired, the NanoTag™ engraved markings were still readable on the pin, although the markings were softening in their sharpness, as a result of peening (figure 5).

The final test involved subjecting the NanoTag™ marking to intentional defacement. The entire process was easily accomplished in approximately one minute's time with no special equipment or knowledge needed. In this case, the sharpening stone used was a fifty-year-old stone that was lying around the house. The tip of a ballpoint pen was used to depress the rear of the firing pin so that the retaining plate could be removed. The firing pin with its spring was then removed. To deface the NanoTag™ markings, the firing pin was placed in the chuck of a portable drill. With the tip of the firing pin placed against the sharpening stone, the drill was spun for about ten seconds. After the initial use of the stone in this manner, a small amount of the marking was still visible at the very tip. Three passes of the sharpening stone by hand removed this last remnant. The number could have been removed in its entirety using the stone by hand

in the same fashion. The firing pin was given one last set of rotations against the stone to dress the edges. The firing pin was then dropped back into the slide with its spring, the rear of the pin was depressed with the ballpoint pen and the retaining plate slid back into position. The pistol was then fired with ten Winchester brand .45 auto caliber cartridges and was found to still be operative. To allow an identification of the firearm's NanoTag™ signature after defacement, the company's literature suggests placing a barcode marking on the side of the pin near the tip. This marking could also be easily removed by simply placing the tip of the rotating firing pin against a piece of abrasive cloth or a sharpening stone. As this firearm is equipped with an inertia firing pin, the pin could have easily been shortened by 0.030 inch or more with almost any type of abrasive material or metal removal tool similar to a file, and the weapon would have still functioned.

The manufacturer marketing this technology has, in its literature, suggested several countermeasures to defeat the intentional defacement of the NanoTag™ identification. These include placing additional NanoTag™ markings on the breechface, extractor, ejector, and the interior of the chamber. This examiner feels that each of these suggestions must be demonstrated and tested and not just given a general acceptance that they will work. Problems that may be encountered with these locations include the following:

- Headstamps present on all rimfire cartridges could interfere with the NanoTag™ impression.

- Rimfire pressures are much lower and hard brass cases seldom show traditional breechface markings. It is anticipated that the cartridge cases will be reluctant to pick up the NanoTag™ impression for the same reason.

- Due to the presence of the centerfire cartridge's headstamp and the hardness of the case materials, NanoTag™ impressions would transfer poorly to areas other than the primer.

- With recoil operated semiautomatic actions of the Browning pistol design, movement of the cartridge across the breechface could cause a loss of information, just as it did with the firing pins. This movement likely would cause shear marks along with wiping which can interfere with the deciphering of the NanoTag™ markings.

- Gas operated semiautomatic actions whose bolts lock and unlock with a rotating movement could suffer similar problems, potentially losing the NanoTag™

Figure 5: Tip of .45 Auto firing pin after 1000 test shots.

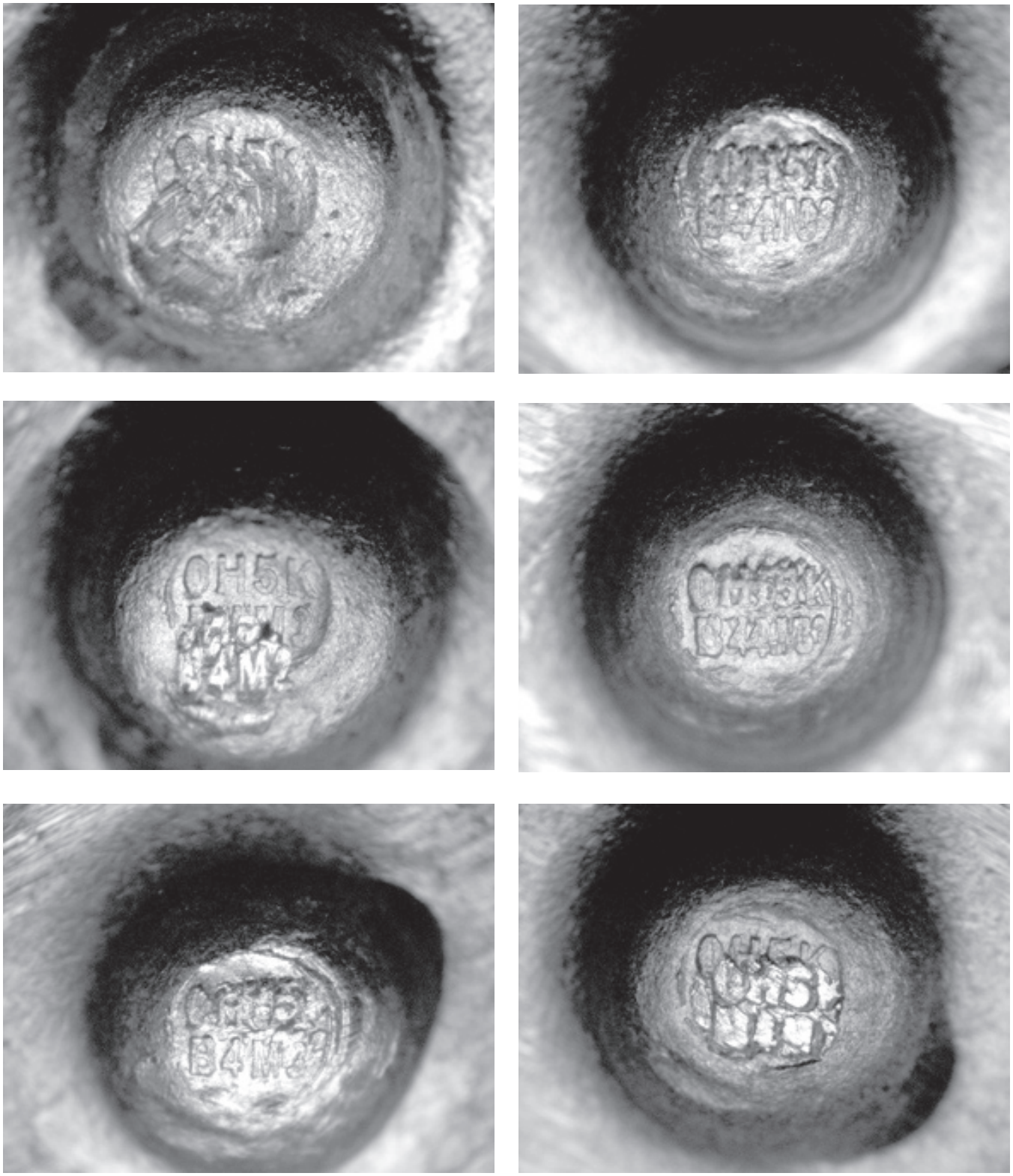

Figure 6: Six examples of "Unsatasfactory" impressions for NanoTag™ identification.

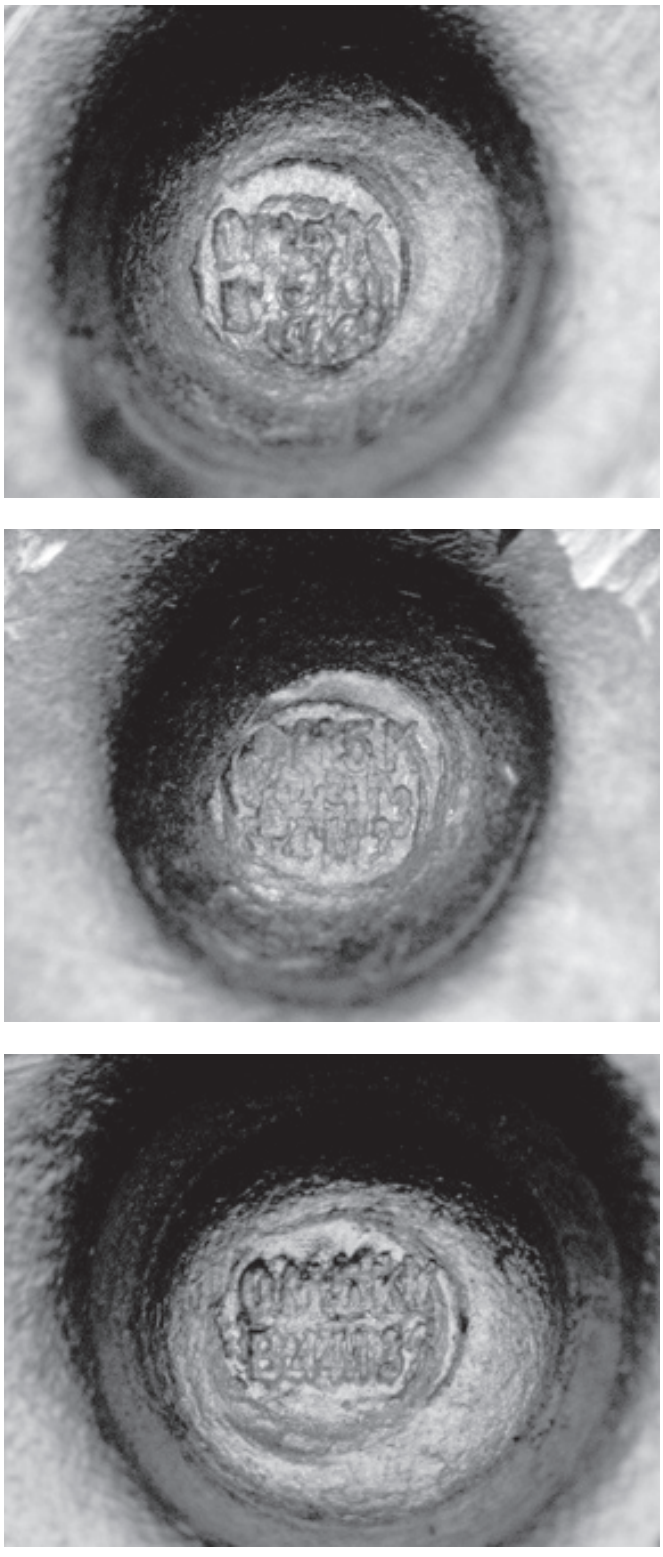

Figure 6a: Three more examples of "Unsatasfactory" impressions for NanoTag™ identification.

markings to shear marks and wiping.

- NanoTag™ engraved markings on the weapon's breechface could be intentionally defaced as easily as those on the firing pin were.

- The company's literature shows a NanoTag™ marking on the extractor and ejector in areas that do not come in contact with a cartridge and cannot mark the case.

- Extractors generally place striated toolmarks on the cartridge rim or extractor groove, which would not work at all well with NanoTag™ marking.

- Headstamp markings present on cartridges often interfere with ejector marks.

- The tip of the ejector, where the NanoTag™ markings would have to be placed to generate an impressed toolmark, would be easily subject to intentional defacement.

- NanoTag™ markings in a chamber would have to be placed deep enough in the chamber to get past the web area of the cartridge. The markings would have to be placed where the case would expand against the NanoTag™ toolmark. These markings would now be exposed to the movement of the case during the extraction process. Still tight against the chamber, the markings would be subject to shearing and wipe, similar to what is seen on a rimfire anvil mark.

- Obviously, variations in ammunition would plague each of the above with its own problems.

The common layman seems to believe that two bullets fired from the same weapon are identical, down to the very last striation placed on them by the weapon. The trained firearms examiner knows how far that is from reality. The layman might also take as gospel that if you could find a way to place a number onto the tip of a firing pin, then you could certainly read it in the impression. Not until this research was performed and many test fires examined from a firing pin that had a known recognizable pattern, did it become apparent how much change could take place, and why matching firing pin impressions can be so challenging. Observing a firing pin mark with four to five overlapping impacts as the result of a single firing was certainly unexpected. After inserting the pin into a number of different firearms and have, in this researcher's opinion, the best made weapon deliver the lowest percentage of readable impressions was also very unexpected. At the same time, the weapon producing the highest percentage of

Figure 7: Image of firing pin impression that was considered "Satasfactory"--microscopically acceptable for NanoTag™ identification.

readable impressions was incapable of firing three shots in a row. Certainly this research has shown that implementing this technology will be much more complicated than burning a serial number on a few parts and dropping them into firearms being manufactured.

Acknowledgements

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