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Comparison of Action Marks on Cartridge Cases Discharged from 9mm Walther P99 Models AS and QA Semiautomatic Pistols on Repeated Firing

Disertation submitted in partial fulfillment for the
Degree of Bachelor of Science in Forensic Science

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ABSTRACT

A firearm identification expert sometimes find it difficult to draw conclusions when comparing fired ammunitions found at the crime scene with the firearm that is recovered after some time interval. During the period, the firearm might have been subjected to any changes due to prolonged repeated firing. This project work investigated any changes and alterations of the action marks recorded on the expended cartridge cases due to repeated firing of 9mm Walther P99 semiautomatic pistols models Anti Stress (AS) (RMP 10248, RMP 10263) and Quick Action (QA) (RMP 61077, RMP 61089, RMP 61100). Each pistol had been repeatedly fired for at least 740 rounds, on the occasion of the shooting practice for police officers of Kelantan State. Cartridge cases of every consecutive of 40th rounds were recovered. Examination using Leica Forensic Solution Comparison (FS C) microscope under magnification x10 to x60 was conducted to observe class and individual characteristics produced by each pistol. Class characteristics of AS and QA models showed many similarities, since they are the variants of the same family of Walther P99. Positive identification between the last cartridge case with the first cartridge case could be made based on breech face marks, firing pin impressions, extractor marks and striation marks that were found on the rim. The study had shown that prolonged repeated firing of guns may cause some changes of action marks but the changes are not significant, hence identification could be made.

INTRODUCTION

Firearms identification is a specialized field in forensic science where fired bullets, cartridge cases, or other ammunition components are identified as having been fired by a specific weapon. It is important to prove that a specific firearm has been used in a shooting incident. The principle of firearm identification is based on the comparison between the questioned ammunition recovered from the scene of the crime with the known ammunition, which is obtained by test-firing using the suspected firearm. This identification is done by examining the class and individual characteristics that are formed on the ammunition components during the firing action of the firearm. These characteristics are also known as action marks, as they are produced during firing mechanism.

Action marks that are found on the fired ammunition are basically in the form of tool marks, as they are formed during the contact between harder material of the firearm's part (e.g. barrel, firing pin etc.) against the softer materials which are the ammunition components (e.g. bullet and cartridge case). These marks are recorded on the fired ammunition in the form of impressions, striations or both. An extensive training, experience and knowledge are required to examine and evaluate these marks.

Class characteristics are the intentional characteristics that would be recognized to represent the identity exhibited by particular group of items; number of lands and grooves, shape of firing pin etc. Any known ammunition which has different class characteristics found on questioned ammunition can be eliminated without further examination. The individual characteristics are the unique characteristics to a specific item and can be used as exclusion to all similar items. They may be produced accidentally due to imperfections or irregularities

during the manufacturing of the firearms; or produced during the usage through the effect of corrosion, erosion or damage. The microscopic textures in the firing pin impressions or breech face marks on expended cartridge cases and the striation marks on fired bullet are some examples of individual characteristics.

Expended cartridge cases are more preferred in firearms identification than fired bullets, as expended cartridge cases may be found at the crime scene without being much affected. Fired bullets may remain inside a body, or being damaged, distorted, fragmented or they may be lost. Further, several studies have shown that expended cases had longer life of individual characteristics (Bonfatti & Kinder, 1999; Kirby 1983) and have a number of marks, which when combined, will give a degree of certainty to match the expended cartridge case with the specific weapon.

Several action marks on the expended cartridge cases can be observed during the firing mechanism of a firearm. These include firing pin marks, breech face marks, extractor marks and ejector marks. Firing pin impression is formed when the weapon's trigger is pulled causing the firing pin to strike on primer cup. The primer mixture will explode and ignite the propellant, generating an amount of gases. These gases will expand and force the bullet to move through the barrel, while the cartridge case moves rearward against breechblock. As the cartridge case slammed against breechblock, the breech face mark is formed. The weapon's extractor will extract the cartridge case, forming the extractor mark on the rim. The cartridge case will then strike against the firearm's stationary ejector to eject the cartridge case through the ejector port, leaving the ejector mark on the cartridge. These action marks may be categorized into class and/or individual characteristics depending on their nature.

The questioned and known fired bullets and/or expended cartridge cases will be compared by using comparison microscope. Comparison microscope is basically two compound microscopes with the same magnification and optical qualities, connected by an optical bridge. Both questioned and known fired ammunition components are compared side-by-side and examined using the eyepiece present on the bridge. The examiner may determine the fired bullets and/or expended cartridge cases being fired by a specific firearm by comparing any distinctive or significant unique surface contours of striations or impressions that present at the surface of both ammunitions, until "sufficient agreement" is achieved.

According to Association of Firearm and Tool mark Examiners (AFTE), 1992, there is some range of conclusion for comparison of tool marks which are identification, elimination, inconclusive or unsuitable. The identification means positive matching between questioned and known ammunitions as the "sufficient agreement" is achieved. Elimination shows that the ammunition was not fired from a specific firearm from the significant disagreement observed between the questioned and known ammunitions. Inconclusive are said when there are insufficient characteristics present on the ammunition and hard to be concluded for either identification and/or elimination. Unsuitable are given when the ammunition is unsuitable for comparison (e.g., the damaged bullets) (Steel, 2008).

There are some difficult situations for the firearm examiner in making conclusions during the process of firearm identification. One of the problems that may arise is that the firearm that was used in a shooting incident was not immediately recovered. It might have been used repeatedly over a period of time. As the firearm was repeatedly used, theoretically, there is a possibility that the interior surface of the firearm parts would be altered after repeated contact with the ammunition, due to the effect of wear, corrosion, erosion and deposition of different

types of particles (Bonfanti & Kinder, 1999). Other circumstances such as storage conditions, maintenance and oxidation of metal due to atmospheric condition might also produce alterations (Vinci *et al.*, 2005).

If the alterations that are formed after several cartridges have been discharged from the firearm are significant, the process of expended cartridge case to be matched back to the weapon would become impossible. Thus, it may be difficult to connect the newly discharged cartridge case with the old one for the lack of reproducibility. The problem of the reproducibility of the action marks on repeated firing of the weapon has been addressed by several workers.

LITERATURE REVIEW

Goddard (1920) examined 500 shots that were fired from one machine gun (unspecified). The fired bullets recovered were then compared and the first fired bullet was positively matched with the 500th fired bullet. (Bonfanti & De Kinder, 1999)

Burrard (1951) fired lead bullets from one revolver (unspecified) and nickel jacketed bullets from a 7.63 caliber pistol (unspecified). The examination of the bullets fired from the revolver showed that the 50th bullet was not matching with the first bullet; and the examination of bullets fired from the pistol showed that the 20th bullet was not matching with the first bullet. The differences were due to the fouling of the land by the lead ammunition. (Bonfanti & De Kinder, 1999)

Hatcher *et al.* (1957) examined the bullets fired from one .50 caliber machine gun (unspecified) and one .45 caliber submachine gun (unspecified). The identification of the .50 caliber machine gun was made if not more than a dozen of shot had been fired, while identification of fired bullets from .45 caliber submachine gun was possible if maximum of 300 to 600 shots had been fired. (Bonfanti & De Kinder, 1999)

Kirby (1983) studied the extent of cartridge cases and bullets marks to change on 900 rounds of ammunition fired from .455 caliber Smith & Wesson revolver, serial number 67137. Identification between the first and the last cartridge cases could still be determined based on breech face marks and firing pin impressions. However, examination of bullets showed changes by the 30th fired round and the changes continue to develop onward, until examination with the 50th showed that a new series of characteristics has evolved, making it doubtful for positive matching.

Ogihara *et al.* (1983) determined the variations that could arise from consecutively fired bullets and cartridge cases. A total of 5000 rounds of ammunition were fired from a .45 caliber Colt Pistol, Model M1911A1 and every 10^{th} (for the first 100) and 100^{th} bullet and cartridge case were recovered for microscopic examination. The result showed that the 5000^{th} cartridge case could still be identified by comparing with the 1^{st} cartridge case, based on the breech face marks, while other marks showed variations, with the ejector marks showed higher variations. The examination of the fired bullets showed that positive identification was possible through all 5000 bullets. However, high variation was observed in the grooves and skid marks.

Hamby (1974) investigated the problem of identification of a bullet to a weapon that had numerous projectiles fired through the barrels. He fired a total of 501 shots by using .223 caliber M16A1 assault rifle, using semi-automatic mode and automatic mode, as fast as the magazine could be changed (makes the barrel hot). He recovered the first fired bullets and each consecutive 100^{th} fired bullets, and compared those fired bullets with each other. He found that the 1^{st} fired bullet could still be matched sufficiently with the 501^{th} fired bullet although there were slight variations in the land and groove striations. He also examined all the expended cartridge cases and showed that they could be matched with one another (Gouwe, Hamby & Norris, 2008; Hamby & Thorpe, 2009). These identifications also were verified by a second qualified firearms examiner (Hamby & Thorpe, 2009).

Shem and Striupaitis (1983) investigated the longetivity of the individual characteristics of fired bullets and expended cartridge cases so that they could be positively matched with the later fired shots. They examined 501 fired bullets and expended cartridge cases fired from a Raven Arms, Model P-25, 25 caliber semiautomatic pistol. The first and each of the

consecutive 50th fired bullets and expended cartridge cases were recovered and examined. The results showed that there was gradual evolution and erosion of the individual characteristics on the fired bullets. However, there were still sufficient characteristics to match between the 1st bullet with the 501th bullet. For expended cartridge case examination, they found out that the breech face of 501th cartridge case could still be identified to the 1st cartridge case, as there were no changes.

Hoet (1989) conducted researches on the reproducibility of cartridge case marks of two 9mm FN High Power pistols and two .357 caliber Smith & Wesson Revolvers (model 19 and 66). 1100 rounds were fired from the pistols and the expended cartridge cases were recovered and examined. He showed that for all four weapons tested, positive identification between 1100th cartridge case with 1st cartridge case could be established based on the breech face impressions. (Bonfanti & De Kinder, 1999)

Schecter *et al.* (1992) studied the reproducibility of the ejector strike in a new Galil Assault Rifle, caliber 5.56 x 45 mm, serial number 2074407 with various brands of 5.56 mm NATO ammunition. A total of 7,100 expended cartridge cases were examined microscopically for their distinctive lines and dots along the right and left sides of the triangle ejector imprint. They stated that there were gradual changes of ejector strike for the first 4,000 rounds that might be due to the plastic deformation of the steel ejector but the changes were not significant, as they were able to match the cartridge case no. 9 with the cartridge case no. 7060.

In February 2001, Brett Doelling presented the research that he conducted involving multiple bullets fired from the same firearm, at the American Academy of Forensic Science Meeting in

Seattle, Washington. 4000 test fire were conducted through a 9x18 mm caliber Makarov semiautomatic pistol. He collected every 100th bullets and examined them microscopically. He showed that the 4000th bullet could still be matched with 1st bullet, although there were some changes of the marks. (Gouwe, Hamby & Norris, 2008; Hamby & Thorpe, 2009)

Chistopher Lucki, had fired a .380 Auto caliber Walther pistol for 150 times and collected the cartridge cases 1, 2, 100, 101, 149 and 150. He discovered that the 1st and 2nd cartridge case could not be matched with other cases, as the breech face marks had changed. In order to investigate the causes of changes, Carter, Milroy and Nguyen (2002) acquired new pistols and fired a minimum of 300 times each. They kept three cartridge cases of each 25 rounds. Included in their study were also four Hi-Point 9mm caliber carbines.

Vinci *et al.* (2005) studied the significant changes of the tool marks on the cartridge cases after firing 2500 rounds of ammunition using a .45 caliber HP (ADLER customized) 1911-A1 semi-automatic Springfield Armory pistol. Twenty five firing sessions were conducted and the expended cartridge cases at every 100th were recovered for the microscopic study. The pistol used was disassembled, cleaned and oiled after each 100 round to prevent the breechblock being affected by the accumulation of residue. The result showed that there were slight changes during the prolonged use of the pistol, but not significant; hence, positive identification could still be established based on the firing pin marks, firing pin drag marks, extractor marks and ejector marks. The breech face marks was not very useful in this study since the presence of the marks was not consistent.

Gouwe *et al.* (2008) designed studies to determine the point at which successive bullets and/or cartridge cases could no longer be identified with the first. Every consecutive 10th expended

cartridge case was collected from the 10,000 consecutively round fired .40 S&W caliber cartridge from a Glock Model 22 semi-automatic pistol. They examined the cartridge cases by utilizing Consecutive Matching Straie (CMS) over using the conventional pattern matching techniques. Examination of the cartridge cases showed that they could be identified with one another, based on the shear marks and breech face marks, even though in a few instances, one side or the other side of the breech area did not replicate.

Uchiyama T. (2008) examined the reproducibility of the landmarks of fired bullets and breech face marks and firing pin marks on the expended cartridge cases of various make. Five ammunitions were used in this study that were Remington brand, DFA brand frangible cartridge and three types of Speer brand (Gold Dot with 147 grain bullet, Gold Dot with 124 grain bullet and Gold Dot with 115 grain bullet). They were fired for one hundred successive rounds using Hi-Point brand, C9 model, caliber 9x19mm semiautomatic pistol, with serial number of P222153. He observed that there were remarkable differences in general appearance of the landmarks due to the usage of different kinds of brand, hence making the identification difficult. Difference of bullet diameter resulted in difference of general appearance of landmarks. On the other hand, the reproducibility of breech face and the firing pin impressions were good. However, due to the different ammunition fired, changes occurred in the number of parallel striations of breech face and circular lines within the firing pin mark.

Saribey *et al.* (2009) assessed the firearm's class and individual characteristics changes over time of the Turkish self-loading pistols. Each pistol was fired a number of times; the Canik 55 1,000 times, the Kanuni 16 2,000 times, the Sarsilmaz Kilinc 2000 2,500 times, the Yavuz 16 3,500 times and the Sahin 08 5,000 times. Overall, the results showed no significant changes of class characteristics but there were some slight alterations of individual characteristics; the

alterations were not significant, hence positive identification could be established. The positive match of the Canik 55 pistol, Sarsilmaz Kilinc 2000 pistol and Yavuz 16 were based on the firing pin impression marks, breech face marks and ejector marks; while the positive match of Kanuni 16 pistol were based on firing pin drag marks, breech face marks and ejector marks; and the positive match of Sahin 08 pistol was based on firing pin drag marks, ejector marks and extractor marks.

Baiti (2009) studied the effect of firing pin marks from the use of different brands of ammunition and repeated firing of firearms. For the study on the effect of repeated firing, she recovered the cartridge cases before and after a shooting competition for police officers, for seven .38 Smith & Wesson Special revolver. During the event, each revolver was fired at least 1200 rounds. The result showed that based on the firing pin marks, the cartridge cases after the shooting competition could be positively matched with the cartridge cases before the event. As an addition to her study, she studied a .38 Smith & Wesson revolver and a 7.65 mm semi automatic Walther pistol, after a period of five years (2004 to 2009). The revolver had been used every year during the shooting competitions, and had been estimated to be fired at least 5000 rounds; while the pistol had not been used since 2004 due to the internal part problem. In the end, even though there were some changes to the firing pin impression features, there were still some significant marks retained, as she was able to positively match the cartridge cases recovered from the 2004, with the cartridge cases recovered in 2009.

Previous study showed that there were some changes of individual characteristics that occurred in the fired bullets and expended cartridge cases. The fired bullets however, showed more alterations in the individual characteristics compared with the expended cartridge cases, especially in the early research such as in Goddard (1920), Burrard (1951) and Hatcher *et al.*

(1957). However, as the technology of manufacturing firearms keeps evolving, the individual characteristics that are produced by the firearm may be either susceptible or prone to changes ranging from hundred to thousand of firings.

This current study is an extension of all of the previous studies and it concentrates on one of the commonly used firearms in Malaysia: Walther P99 semiautomatic pistol, model Anti Stress (AS) and Quick Action (QA). Previous study had shown the occurrence of alteration in the breech face marks by Walther pistol of a different model (Carter, 2002). This current study attempts to investigate the rate of changes that may be present on the individual marks after being fired repeatedly by Walther P99 semiautomatic pistol, models AS and QA. Also the rate of change may be assessed among same models of pistols, as there are at least two pistols of each model involved in this study.

The Walther P99 semiautomatic pistol is manufactured by Carl Walther GmbH Sportwaffen of Ulm. It uses an internal striker as opposed to an external hammer, with a red-painted striker tip that protrudes from rear of the slide when the gun is cocked, as well as a loaded chamber indicator on the right side of the slide. Some of the variants of Walther P99 are Anti Stress (AS) model and Quick Action (QA) model. The Walther P99 AS variant features single or double action with the capacity of 15 rounds, and equipped with a specialized trigger, ergonomic grip, adjustable sights, and 4 inch barrel. It functions as a sort of two-stage trigger, and lessens the possibility of stress-induced negligent discharges. The Walther P99 QA variant is designed around a hammerless spring activated firing pin or "striker" like the Glock style action. When the trigger is pulled, the striker is fully cocked and released, firing the pistol. The trigger pull is consistent in length and force from the first shot to the last. (Walther Pistols, 2010; Wikipedia, 2011)

In Malaysia, Walther P99 semiautomatic pistols model AS and QA are among the common firearms used. They are one of the firearms that are officially used by the Royal Malaysia Police. They are also used by the criminals, as the pistols have been smuggled from outside the country.

OBJECTIVES OF THE STUDY

The aim of this research is to assess the occurrence of changes or alteration of the action marks produced by the 9mm Walther P99 semiautomatic pistols models AS and QA on the expended cartridge cases. In order to achieve the aim, several following objectives should be accomplished.

1. To identify and evaluate the class and individual characteristics on the expended cartridge cases fired by the above pistols
2. To determine whether the marks produced change after several hundred rounds are fired repeatedly from each pistol
3. To check if the rate of change (if present) of the individual marks is similar or not among the same model of pistols

MATERIALS AND METHODS

A. Firearms

Five Walther P99 semiautomatic pistols were used in this study, which consisted of two AS and three QA pistols. These pistols were fired during the shooting practices for the police officers of Kelantan State. The details of the pistols are described below:

Firearm : Walther P99

Type : Semiautomatic pistol

Model : Anti Stress (AS) and Quick Action (QA)

Manufacturer : Carl Walther GmbH Sportwaffen

Made in : Germany

Serial number :

i. Walther P99 Anti Stress
   a. RMP 10248
   b. RMP 10263

ii. Walther P99 Quick Action
   a. RMP 61077
   b. RMP 61089
   c. RMP 61100

B. Ammunition

Only one type of ammunition of the same manufacturer was used, composition and same batch. The use of other types of ammunition with different manufacture, composition, and/or batch might affect the results. This ammunition was fired by the police officers of Kelantan State during the shooting practice. The details of the ammunition are described below:

Manufacturer : Syarikat Malaysia Explosive (SME) Ordnance Sdn. Bhd.

Caliber : 9 x 9 mm

Type : Full-metal jacketed

Batch : 1-07

Metal : Brass

C. Sample Collection

The test firing and the collection of the cartridge cases were conducted during the occasion of shooting practice for the police officers of Kelantan state. It was conducted at the Gunong Police Firing Range at Gunong, Kelantan for three days starting from May 24 to 26, 2010. See Appendix II for more information.

Each Walther P99 pistols was fired for at least 700 rounds (refer Table 1) during those three days. The first five of the expended cartridge cases from each pistol were collected. Then, three of expended cases for every consecutive 40^{th} round were collected. Refer Appendix III for details.

The expended cartridge cases collected were separated from one another and each cartridge case was kept in a separate envelope. The envelope was labelled with the serial number of the pistol and the number of round discharged.

Figure 1: The shooting practice for the police officers of Kelantan State at Gunong Police Firing Range, Kelantan.

	Serial Number	Total Ammunition Fired	Total Expended Cartridge Cases Collected
Walther P99 AS	RMP 10248	742	64
	RMP 10263	742	64
Walther P99 QA	RMP 61077	762	65
	RMP 61089	802	66
	RMP 61100	742	62

Table 1: The expended cartridge cases collected from the five pistols.

D. Equipments

The Leica FS C (Forensic Solution Comparison) Microscope, serial number 264813 (Figure 2) was used to compare the expended cartridge cases. The cartridge cases were mounted at the adjustable cartridge case holder on the stage. The comparison microscope featured four macro objectives which could be further magnified with motorized 1.5x magnification changer, enabling the comparison magnification ranging from 4x magnification to 60x magnification. The cartridge cases were observed with split image mode with variable dividing line; and full image, either right or left can be obtained. There was also superimposed image mode.

Figure 2: Leica FS C (Forensic Solution Comparison) Microscope integrated with Cold Light Source KL 2500 LCD fiber optic illumination, Leica DFC 290 digital camera and Leica Application Software (LAS).

The comparison microscope was integrated with either digital camera (Leica DFC 290) or film camera (Leica MPS 60 and Leica MPS 60 Shutter Piece) for documentation. The comparison microscope was connected and integrated to the computer with the software Leica Aplication Software (LAS) for documenting digitally and with some manipulation of lighting.

The Cold Light Source KL 2500 LCD was used for intensive illumination for the examination of cartridge cases. It could be rotated so that the cartridge cases were illuminated from different angles for enhancement of observing the individual marks. The intensity of light was manipulated manually or by using the LAS software.

E. Initial Examination of Cartridge Cases

For each firearm, the first five cartridge cases were examined under the comparison microscope to establish the class and the individual characteristics. Such characteristic such as shape and locations for the striations and impression patterns were examined. These characteristics were used later to compare with further expended cartridges.

The cartridge cases were also examined initially at the area of the sealant paint around the primer cup. It was observed if there was any mark that had been left by the pistol on the sealant paint, such as breech face marks. If there were any marks observed at the sealant paint, it was documented by photographs and notes.

F. Cleaning of the Cartridge Cases

Sealant is particular type of paint that is usually found on the cartridge cases around the primer cup. The function of the sealant is to hold the primer cup on the cartridge case as well

as to prevent any leaking of primer mixture and exposing to the atmosphere (Larrison, 2006). Sometimes the sealant is used for the identification of the manufacturer.

Dust and any other particles that may come from the gun (the gun powder residue) or the environment (after the ejected cartridge case fall onto ground) will adhere to the base of cartridge head covering some marks on the cartridge case base. Hence, the sealants, and any adherent dust and particles should be removed from the cartridge case, so that the marks become clearer for comparison.

The cartridge cases was cleaned by using alcohol (e.g.: methanol) or acetone. Acetone showed to be a better solution for cleaning, as it worked faster and easier than ethanol in removing the sealant. A cotton bud was dipped into the reagent and then slowly swabbed onto the surface of the cartridge cases head. A magnifying glass (x2) was used to check if there was any sealant or any other residue left or any fiber from the cotton bud remained at the cartridge case.

G. Comparison of the Expended Cartridge Cases

From the initial examination, one cartridge case was selected among the first five that gave clearer marks compared to the other four. This cartridge case was compared with every one of the successive 40 consecutive expended cartridge cases.

For comparison, the firing pin drag mark was used as a guide. The firing pin drag mark was set at 3 o'clock except for examination and comparison of firing pin impressions, which required rotations to certain positions, depending on the appearance of the marks. The extractor mark was observed on the rim and inside the groove.

The examination was done by using magnification ranging from 10x to 60x. Lower magnification was used for impression marks, while higher magnification for striation marks. The light was adjusted to a suitable angle for a better visualization of the individual marks.

Each comparison between the 1st cartridge case with each of 40 consecutive round cartridge case was documented by photographs taken by the Leica MPS 60 film camera and LAS software using Leica DFC 290 digital camera. The digital images were then saved into a file. Any matching or any alterations in the marks were noted and sketched inside a logbook.

RESULTS AND DISCUSSION

All of the cartridge cases discharged from both models AS and QA of the Walther P99 pistols were examined. Class and individual characteristics for each model were established. The class characteristics are the characteristics or any marks which are similar within the same model. The individual characteristics were then examined so that the identification of the cartridge cases to the specific firearm could be done. It is essential that the class and individual characteristics should be reproducible and consistent, so that any cartridge case can be identified even comparing to those fired in the next hundred of intervals.

Examination of the Class Characteristics

Basically, all the class characteristics of both model AS and QA were found to be similar. There were some differences between them, but still not sufficient enough to use for distinguishing between models. This might be due to the fact they are the variants from the same family, which is Walther P99 pistols.

The firing pin impression for both models AS and QA of the Walther P99 pistols showed similar features. The firing pin impressions were indented in circular shapes. Along with the circular indentation, there were also firing pin drag marks (Figure 3).

Figure 3: Firing pin impression produced by AS model (left) and QA model (right).

Photomicrograph, x7.1.

The breech face of the Walther P99 AS model had two types of breech face markings. The first type of breech face marks showed the impressions of lines that were parallel to one another spread throughout the base of the primer head (Firdaus, 2010). The lines were broad or narrow, or a mixture of both. The second type of breech face marks observed was the small impression that appeared like striations at the surface of the primer cup just beside the firing pin drag mark. However, the other model QA model did not show any breech face marks. Only one QA pistol showed a small portion of breech face marks.

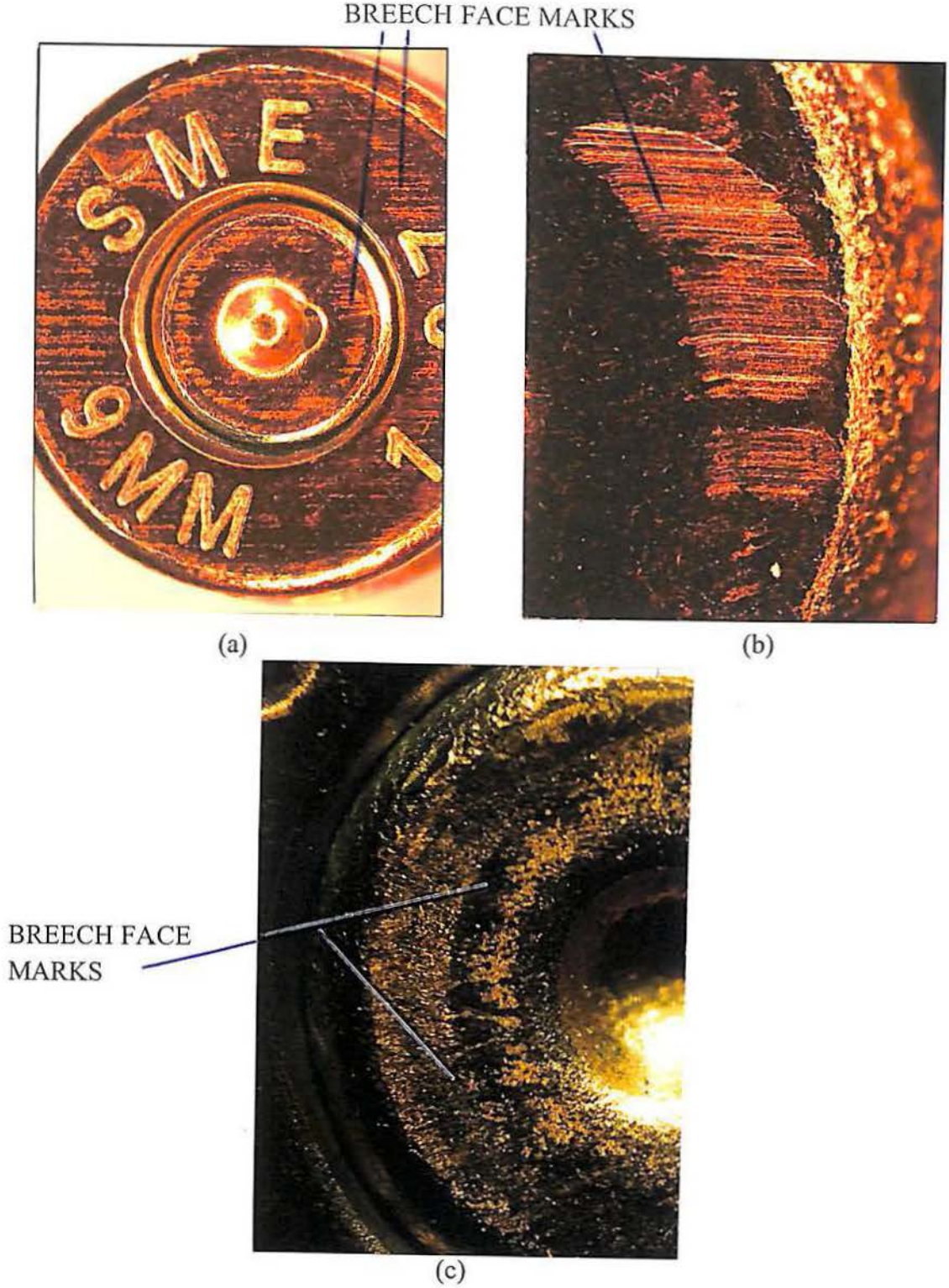

Figure 4: Breech face marks of AS model: parallel line impression that runs through the entire base, x10 (a) or a group of striations near to the firing pin drag marks, x63 (c). Breech face of QA model was not well delineated, only a portion of breech face marks is observed at the primer cup (c), x20.