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EXPERIMENTAL STUDY OF BULLET HOLES ON ALUMINIUM TARGETS FIRED WITH 9 MM PISTOL AND 9 MM SUBMACHINE GUN (SMG) AT VARYING DISTANCES

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ABSTRACT

All the guns have their own unique identifying features and even if the gun has not been left at the crime scene many degrees of information can be determined from the bullet, bullet holes on the targets, the nature of the wound and any residue that is left around it. Researchers have conducted studies about the evaluation and reconstruction of fired bullet paths delivered in indoor scenes and their performance in a unique environment. Bullet performance is typically a function of the matrix in which the bullet interacts. The identification of bullet holes is based, besides the morphology of the hole in question, on the presence of gunshot residue and of blackening in the vicinity of the hole. It is shown that field tests were conducted by police agencies and researchers to discover the relationship between bullet holes on different types of targets and firearms. The present study was aimed to conduct an experimental study of bullet holes on aluminium targets fired with 9 mm pistol and 9 mm submachine gun with varying distances which formed a database for forensic application. The shooting exercise was conducted at Sungai Buloh shooting range by trained firearm experts, Polis Di Raja Malaysia, Bukit Aman, Kuala Lumpur.

Key words: Forensic science, 9 mm pistol, 9 mm SMG, aluminium targets, bullet holes

INTRODUCTION

During investigative proceedings of incidents involving the use of firearms, forensic expertise can provide key elements for the court to reach an opinion. In such context, particular attention is usually drawn to evaluative issues associated with firearms and related evidence such as gunshot residues (Laurent, 2007; Druid, 1997). In many firearm crime scenes the investigators cannot find out any bullets or their castings but the available firearm evidence is the presence of bullet holes on various objects including human dead bodies (Katerina *et al.*, 2009; David & Carin, 2008). When there are bullet holes in the victim or in other objects at the scene, specialists can determine where and from what height the bullet was fired from, as well as the position of the victim when it was fired. Researchers have conducted studies about the evaluation and reconstruction of fired bullet paths delivered in indoor scenes (Gardner *et al.*, 2009; Haag & Lucien, 2006; Trahin, 1987; Bunch & Stephen, 1998) and their performance in a unique environment (Noedel, 2010). Many firearm experimental studies were conducted relating different types of firearms with variety of targets material with varying objectives and the result of the investigation can be used to utilize in real crime scenarios. Several investigations were conducted on effect of projectile nose shape, impact velocity and target thickness on deformation behaviour of various target materials (Borvik *et al.*, 2002; Camacho & Ortiz, 1997; Chocron *et al.*, 2001; Corran *et al.*, 1983; Damoder *et al.*, 2001; Gupta *et al.*, 2006). The characterisation of bullets holes on targets like glass (Stahl *et al.*, 1979; Albanese *et al.*,

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1984; Thornton & Cashman, 1986), paper board (Mulani *et al.*, 2016), plywood (Nattapontangtawee & Weerachaiphutdhawong, 2015), metal sheets (Jeremy *et al.*, 2013) multi-layered metal sheets (Flores-Johnson *et al.*, 2011), helmet (Naday & Baruch, 2001) and concrete walls (Scott *et al.*, 2002) were studied in different countries and manufacturers. Literature review shows that no study was conducted to investigate bullet holes on aluminium targets fired with 9 mm pistol and 9 mm submachine gun at varying distances. Hence the present experimental study was aimed to investigate the bullets holes fired on aluminium targets fired with 9 mm pistol 9 mm submachine gun at varying distances.

MATERIALS AND METHODS

As suggested by Polis Di Raja Malaysia, Bukit Aman, Kuala Lumpur, the experimental shooting exercise was conducted at Sungai Buloh shooting range, Selangor state by trained police firearms experts. The target used was six numbers of 4 mm thickness aluminum plates with size of 210 mm x 148 mm available in Malaysia. Following PDRM protocol, each metal target was fired with 9 mm pistol and 9 mm submachine gun (SMG) at a distances of 15m, 20m, 30m and 35 m respectively. The shape of the bullet holes are mostly irregular and is cumbersome to measure the accurate diameter. Hence the circumference of the bullets holes were measured using string technique. Stringing has been used at crime scenes of firearms and blood spatter. (Gregory, 2003; DeFrance *et al.*, 2009). All the bullet holes were photographed and recorded the measurements.

RESULTS & DISCUSSION

Fig. 1 depicts the appearance of bullet holes on front and rear side of the 4 mm aluminium sheets (entry and exit holes) fired at a distance of 15m, 20m, 30m and 35m by using 9 mm pistol. All aluminium sheets are of same size (210 mm x 148 mm) with 4mm thickness and separate target sheet was used for each firing and thus 12 aluminium sheets were used for this experimental firing exercise. Each resulting bullet hole was examined and measured by "stringing" technique and recorded the measurements.

Table 1 presents the descriptive statistics of firing range, entry and exit bullet hole circumferences, weight of the metal before and after firing. The investigation reveals that the size of entry hole (front side) is comparatively larger than the exit hole (real side). It is interested to note that at a firing distance of 20 m, no hole was formed but showing deep dent mark of 6 m depth with a diameter of 57 mm. External or exterior ballistics is concerned with the flight of the projectile from the muzzle to the target. This is involving parameters such as bullet shape, sectional density, atmospheric pressure and other environmental factors. These factors can affect the penetration power (Brian, 2008). The major forces which exert their inference upon the bullet include gravitational force and the resistance of the

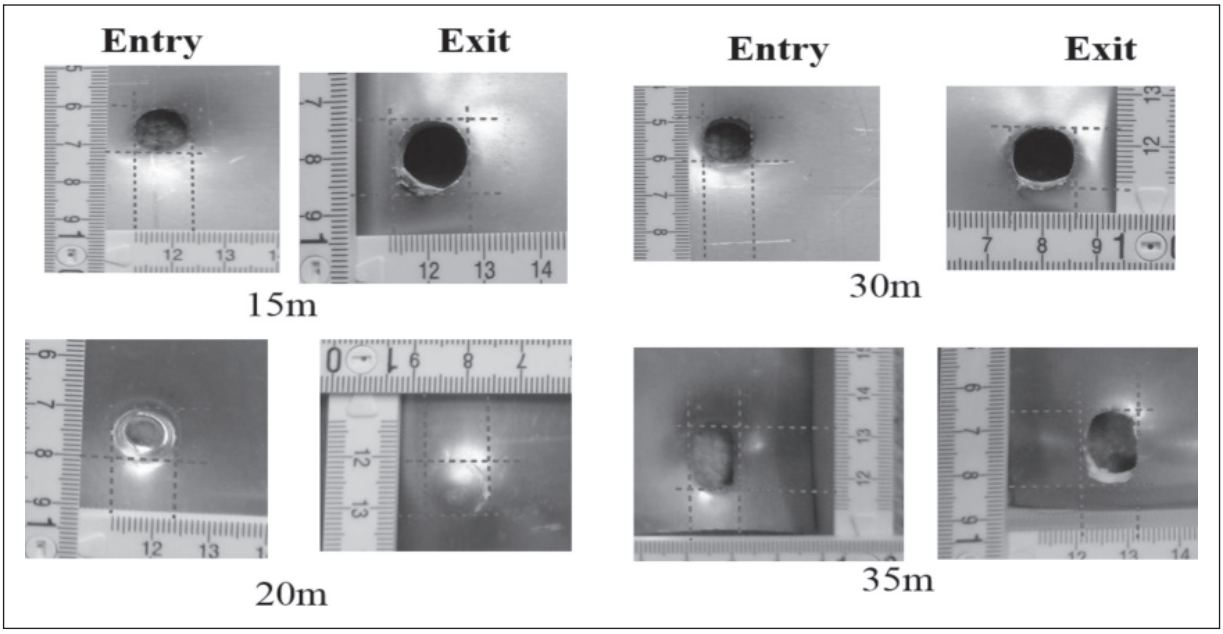

Fig. 1. Entry and exit holes aluminium metal sheets fired with 9 mm pistol at varying distances.

Table 1. Descriptive statistics of bullet holes circumference (in mm) on aluminium targets fired with 9 mm pistol at varying distances and changes in weight

Trial No.	Firing range (meter)	Size of entry hole (front side)	Size of exit hole (rear side)	Weight of metal before firing (g)	Weight of metal after firing (g)	Weight loss (g)
Plate 1	15	38	46	355	349	6
Plate 2	20	41 (inward dent)	Outward dent (6mm depth, 57 mm dia)	355	351	4
Plate 3	30	42	47	355	348	7
Plate 4	35	55	57	355	344	11

opposing wind forces which slow the velocity of bullet (Tom Warlow, 1996). When the firing exercise was conducted at a distance of 20 m on plate 2, the climate was cloudy and drizzling and the effect was indicated by the formation of dent mark rather than penetration since the velocity of the bullet was retarded by the environmental factor. The target did not show any hole but showing inward dent of 41mm and outward dent of 57 mm (Fig. 1). The investigation shows that there is an increase trend in weight loss except metal 2 showing tent mark only. The size of the entry hole is smaller than exit hole. The study on bullet holes fired by different types of bullet on sheet metal and wooden board have shown significant difference that can be used to identify the type of bullet (Nattapontangtawee & Weerachaiphutdhawong, 2015). A study of characterisation of bullet holes in helmet made of composite materials indicated whether the hole is from bullet entrance or exit (Nadav & Baruch, 2001). Fig. 2 depicts the appearance of bullet holes on front and rear side of the 4 mm aluminium sheets (entry and exit holes) fired at a distance of 15 m, 20 m, 30 m and 35 m by using 9 mm SMG. The entry hole (front side) is smaller than the exit hole (rear side) as observed in the previous firing exercise by 9 mm pistol.

Table 2 presents the descriptive statistics of firing range, entry and exit bullet hole circumferences, weight of the metal before and after firing. The investigation reveals that irrespective of distance, the size of entry hole (front side) is comparatively larger than the exit hole (real side). The size of entry and exit hole did not show variation (40 mm) in the plate when fired at a distance of 15 m and the variation is very less (40 and 41 mm) when fired at a distance of 20 m. Appreciable variation in size were observed between entry and exit holes when the range of fire is 30 m (41 and 47 mm) and 35 m (50 and 57 mm). As the range of firing increases, the size of the hole showed upward trend. The researchers have been measuring the bullet holes through diameter. But size of the bullets holes are not uniform in size, in the present study to measure the size of bullet holes, circumference measurement was used by stringing

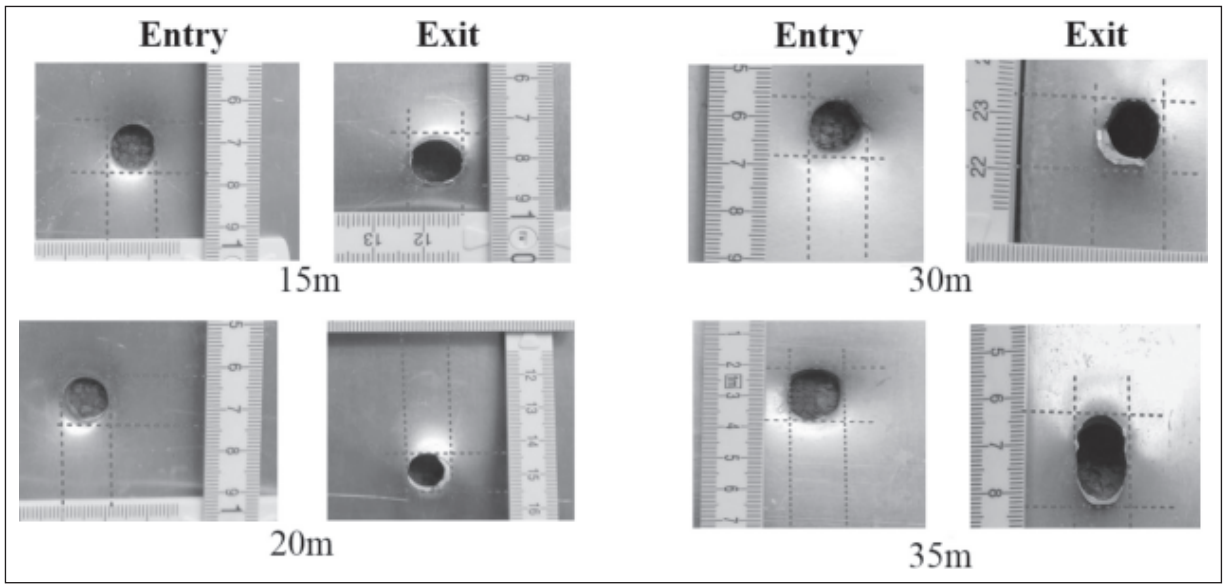

Fig. 2. Entry and exit holes aluminium metal sheets fired with 9 mm SMG at varying distances.

Table 2. Descriptive statistics of bullet holes circumference (in mm) on aluminium targets fired with 9 mm SMG at varying distances and changes in weight

Trial No.	Range of fire (meter)	Size of entry hole	Size of exit hole	Weight of metal before firing (g)	Weight of metal after firing (g)	Weight loss (g)
Plate 1	15	40	40	355	342	13
Plate 2	20	40	41	355	347	8
Plate 3	30	41	47	355	341	14
Plate 4	35	50	57	355	346	9

method so that accurate measurements were achieved (Gregory, 2003; DeFrance *et al.*, 2009). The entry holes are comparatively smaller than exit holes. The penetration effect on aluminum targets were influenced by the shape, impact velocity of the projectile and thickness of the targets (Gupta *et al.*, 2006).

CONCLUSION

The legislation of firearms control is extremely strict almost in all countries including Malaysia. The terminal ballistic effects on the aluminium plate provide valuable information to the investigators in the form of bullet holes. The entry holes are comparatively smaller than the exit holes when fired with 9 mm pistol and 9 mm submachine gun in various range of fire. But the size of entry holes and exit holes produced by 9 mm SMG are found to be smaller than the entry and exit holes produced by 9 mm pistol. The size of bullet holes provided valuable information to recognize the range of firing and type of weapon used in real crime scenarios. Once the suspected weapon is seized, it is advisable to conduct test firing with the suspected firearm and then to compare the crime scene bullet holes and test bullet holes so as to arrive a definite conclusion and further to prove this fact in the court of law.

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REFERENCES

Albanese, M., Moody, J. & Rayl, T. 1984. A study of intermediate glass barrier effects on police tactical weapons effectiveness. *The Tactical Edge*, Spring, 15-19 pp.

Borvik, T., Langseth, M., Hopperstad, O.S. & Malo, K.A. 2002. Perforation of 12 mm thick steel plates by 20 mm diameter projectiles with flat, hemispherical and conical noses part I: experimental study. *International Journal of Impact Engineering,* **27**: 19-35.

Brian J.H. 2008. Handbook of Firearms and Ballistics. Second edition. A John *Wiley & Sons Ltd*., Publication, 109-110 pp.

Bunch & Stephen G. 1998. Some proposals for standardizing trajectory analysis and reporting. *The Association of Firearm and Tool Mark Examiners Journal,* **30(3**): 482.

Chocron, S., Anderson Jr., E.C., Grosch, D.J. & Propelar, C.H. 2001. Impact of 7.62-mm AMP2 projectile against the edge of a metallic target. *International Journal of Impact Engineering,* **25**: 423-437.

Corran, R.S.J., Shadbolt, P.J. & Ruiz, C. 1983. Impact loading of plates – an experimental investigation. *International Journal of Impact Engineering,* **1(1)**: 3-22.

Camacho, G.T. & Ortiz, M., 1997. Adaptive Lagrangian modelling of ballistic penetration of metallic targets. *Computer Methods in Applied Mechanics and Engineering,* **142**: 269-301.

DeFrance, Charles, S., Rosati & Carlo, J. 2009. A practical guide to shooting scene preservation for crime scene investigators. *Journal of the Association for Crime Scene Reconstruction*, **15(3)**: 29-39.

Druid, H. 1997. Site of entrance wound and direction of bullet path in firearm fatalities as indicators of homicide versus suicide. *Forensic Science International,* **88(2)**: 147-162.

Damoder, R.A., Jaunky, N., Lawson, R.E. & Knight Jr. 2001. Numerical simulations for high energy impact of thin plates. *International Journal of Impact Engineering*, **25**: 683-702.

David, A.L. & Carin, M.V. 2008. A mystery: One wound, multiple bullets. *Journal of Forensic Science and Legal Medicine,* **15(5)**: 343-345.

Flores-Johnson, E.A., Saleh, M. & Edwards, L. 2011. Ballistic performance of multi-layered metallic plates impacted by a 7.62-mm APM2 projectile. *International Journal of Impact Engineering,* **38(12)**: 1022-1032.

Gardner, R.M. & Tom Bevel. 2009. Practical crime scene analysis and reconstruction. Chapter 7: *Shooting Scene Processing and Reconstruction*, Boca Raton: CRC Press, 131-174 pp.

Gupta, N.K., Iqbal, M.A. & Sekhon, G.S. 2006. Experimental and numerical studies on the behaviour of thin aluminium plates subjected to impact by blunt- and hemispherical-nosed projectiles. *International Journal of Impact Engineering,* **32**: 1921-1944.

Haag. & Lucien C. 2006. Shooting Incident Reconstruction. *Amsterdam*: Elsevier.

Gregory, A.P. 2003. Stringing a Crime Scene to Determine Trajectories. *Journal of Forensic Identification*, **53(4)**: 435-443.

Jeremy, D., Seidt, Pereira, J.M., Gilat, A., Duane, M., Revilock & Nandwana, K. 2013. Ballistic impact of anisotropic 2024 aluminium sheet and plate. *International Journal of Impact Engineering,* **62**: 27-34.

Katerina, P., Francisco, T., António, J.M., Agostinho, S. & Teresa, M. 2009. *Journal of Forensic Science and Legal Medicine* **16(7)**: 407-410.

Laurent, M., Alain, A., Cristina, C. & Eric, B. 2007. A deceptive case of gunshot entry wounds – Beware of frangible bullets. *Journal of Forensic Science and Legal Medicine,* **14(3)**: 161-164.

Mulani, K., Kadam, M., Ghadage, G. & Ranindra, J. 2016. Study of estimating firing distance based on pellets distribution on targets from country made pipegun. *Research Journal of Forensic Sciences,* **4(3)**: 1-5.

Nadav, L. & Baruch, G. 2001. Characterisation of bullet holes in helmets made of composite materials: A case study. *Problems of Forensic Sciences,* **26**: 303-310.

Nattapontangtawee, T. & Weerachaiphutdhawong, ICP. 2015. Bullet damage analysis on sheet-metal and wooden boards. *Chemical Science Transactions,* **4(3)**: 668-671.

Noedel, M. 2010. Studying fired bullet performance in a unique environment. *Journal of the Association for Crime Scene Reconstruction* **16(3)**: 27-36.

Stahl, C.J., Jones, S.R., Johnson, F.B. & Luke, J.L. 1979. The effect of glass as an intermediate target on bullets: Experimental studies and report of a case. *Journal of Forensic Sciences,* **24(1)**: 6-17.

Scott, D.K., Marc, D.K. & Michael, A.H. 2002. Resistance of exterior walls to high velocity projectiles, *Technical Report,* Royal Canadian Mounted Police.

Trahin, J.L. 1987. Bullet Trajectory Analysis. *Association of Firearm and Tool Mark Examiners Journal,* **19(2)**: 124.

Thornton, J.I. & Cashman, P.J. 1986. The effect of tempered glass on bullet trajectory. *Journal of Forensic Sciences,* **2**: 743-746.

Tom Warlow. 1996. *Firearms, the Law and forensic ballistics*. Second edition. *CRC Press, New York*. 127-130 pp.