Forensic Science International 192 (2009) e17–e20

Contents lists available at ScienceDirect

Forensic Science International

journal homepage: www.elsevier.com/locate/forsciint

Short communication

Estimating the shooting distance of a 9-mm Parabellum bullet via ballistic experiment

F. Bresson *, O. Franck

INPS, Laboratoire de Police Scientifique, 7 bd Vauban, 59000 Lille, France

ARTICLE INFO

Article history:
Received 26 May 2009
Received in revised form 20 July 2009
Accepted 28 July 2009
Available online 4 September 2009

Keywords:
Firearm
Bullet

ABSTRACT

We demonstrate here how the shooting distance of a 9-mm Parabellum FMJ bullet (115gr) has been estimated via shooting experiments. Such a bullet was found by investigators near a concrete wall, fairly distorted at its tip. The bullet carries no evidence of multiple impact and no evidence of ballistic impact on the wall has been reported. We estimated the impact velocity by comparing the questioned bullet with a set of comparison bullets hitting a wall (rigid target) with different velocities. The shooting distance was recovered from the impact velocity by studying the typical behavior of a manufactured 9 mm bullet weighting 115 g (7.45 g), shot in pistol or a sub-machine gun. The results demonstrated that the questioned bullet was a lost bullet. The shooting distance also helped the investigators, narrowing the range of the estimated positions of the shooter.

1. Introduction

The ballistic department of the Forensic Science Laboratory in Lille was requested to give any helpful information about a urban gunshot. A firearm bullet, found near a concrete wall in a urban area, has been seized by investigators. A witness described how he saw a bullet falling down beside his feet after hitting a wall. The bullet is a 9-mm Parabellum FMJ (Full Metal Jacket) bullet weighting 115gr (7.45 g). It remained complete with its jacket unbreached after impact. The observed distortion is fairly small, and limited to the tip of the bullet. The bullet carries no evidence of multiple impact. The tip of the bullet shows evidence of impact against a rough and hard target under normal incidence. No evidence of ballistic impact (scratches or matter ablation) on the wall has been reported.

Beside the normal characterization (barrel twist, caliber, type of weapon), investigators questioned us whether it was possible to give the shooting distance.

In such a gunshot, only one impact is involved. No information about the position of the shooter can be given as the classical way to recover the trajectory is to draw the straight line passing by at least two consecutive impacts [1]. Another limitation of the classical way to recover a gunshot trajectory is the lack of knowledge about impact phenomena like deflection, velocity loss, bullet integrity and stability. These phenomena are qualitatively known [2–4] but not always quantified, even though their influence can be critical with long range gunshot and/or high incidence impacts.

According to our experience, a firearm shot involving 9 mm bullets hitting a concrete wall within a typical combat distance (0–50 m) would leave a fragmented bullet. In this situation, our answer would be that the shooting distance is far beyond 100 m, and it is likely that the wall was not the target.

The approach we propose is to compare the questioned item (bullet or impact support) with a set of comparison item in which impact parameters (velocity and/or incidence angle) vary. These comparison item are obtained via ballistic experiments. In our case, the only parameter that may vary is the impact velocity.

2. Materials and methods

We used a Glock 26 semi-automatic pistol for the experiments. The target was a 50 mm thick concrete plate. The shooting distance is set to 2 m. Different velocities were obtained by varying the amount of propellent (Vectan Ba 9) in home-made 9 mm Parabellum cartridges. The reloaded bullets are 9 mm Parabellum lead core FMJ (weight, jacket material, bullet's shape are similar to the questioned bullet). The impact velocity is measured half way between the pistol and the target with a commercial chronograph. Very low velocities (down to 35 m/s) were predictively obtained. Such a low velocity impact can simulate a 2 km and beyond shooting distance.

3. Results

For each experiment, the length (l) and the diameter (D) of the bullet were measured and plotted versus the impact velocity. The curves are given in Fig. 1. The figure also includes pictures of the questioned and the comparison projectiles (each comparison

* Corresponding author. Tel.: +33 320 12 89 51.
E-mail address: fbresson@yahoo.com (F. Bresson).

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doi:10.1016/j.forsciint.2009.07.018

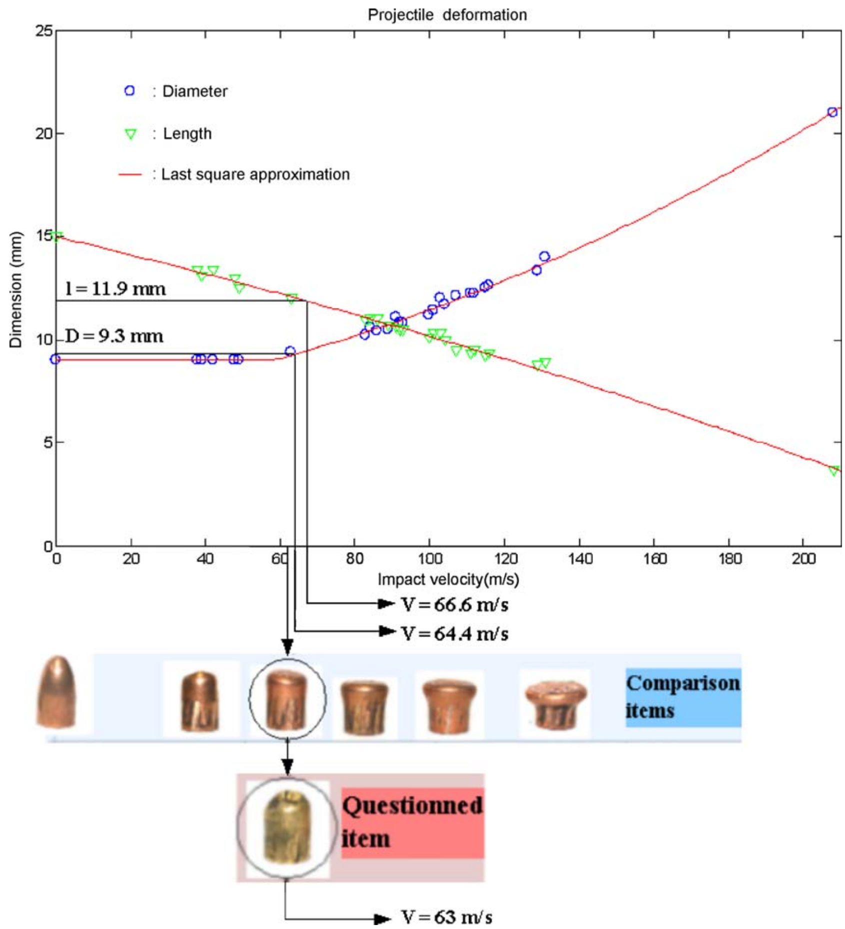

Fig. 1. Dimension of the bullet (length and diameter) for various impact bullet velocities.

projectile is disposed along the x-axis according to its impact velocity).

In Fig. 1, the behavior of l was smoothed by a least square approximation (second degree polynomial function). The behavior of D was only smoothed in the velocity range where the projectile starts to expand. The smoothed function is also a second degree polynomial function calculated by least square method. This polynomial function intersect $D = 9$ mm at $V = 58.33$ m/s. Below this threshold value, the value is set to 9 mm (the original diameter).

The total length of the bullet starts to decrease even for very low impact velocities. The curve is supposed to follow a smooth behavior, the accidents being due to experimental uncertainties. The measurement of the length may not be accurate if the tip of the bullet presents a significant roughness. This is actually the case in our experiment, both with the questioned item and the comparison set of items.

The behavior of the maximum diameter is less suitable for comparison as it remains constant till the tip expends more than the base. However, it is interesting to compare the diameter as it can be more accurately measured than the length, especially in the investigated case.

The questioned bullet length and diameter are respectively 11.9 mm and 9.3 mm. Table 1 gives the value of these parameters for all the comparison experiments. The table shows that the experiment with an impact velocity of 63 m/s gives a length and a deformation very similar to the questioned bullet. On the qualitative point of view, Fig. 1 shows that $V = 63$ m/s gives a deformation shape very close to the questioned item. Using the

Table 1
Characteristics of the comparison bullets and the questioned bullet.

Velocity (m/s)	Length (mm)	Diameter (mm)
0	15,0	9,0
38	13.4	9.0
39	13.1	9.0
42	13.4	9.0
48	13.0	9.0
49	12.5	9.0
63	12.0	9.4
Questioned bullet	11.9	9.3
83	10.9	10.2
84	11.0	10.6
86	11.0	10.4
89	10.7	10.5
91	10.6	11.1
92	10.5	10.8
93	10.5	10.8
100	10.1	11.2
101	10.3	11.4
103	10.3	12.0
104	10	11.7
107	9.5	12.1
111	9.3	12.2
112	9.5	12.2
115	9.2	12.5
116	9.3	12.6
129	8.8	13.3
131	8.9	14.0
208	3.7	21.0

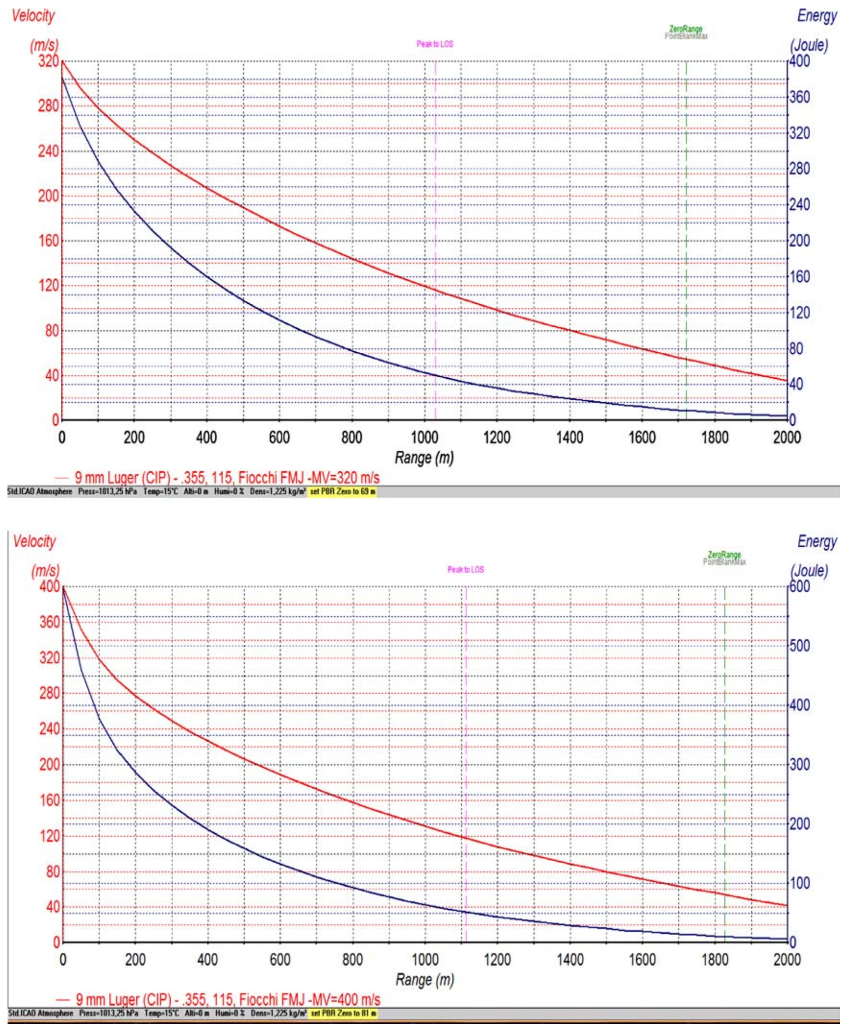

Fig. 2. Deformation criterion C for various impact bullet velocities. Blue squares are the experimental values. Red line is a least square approximation by a polynomial function (second degree).

least square approximation to determine the impact velocity can be done, both with the length and the diameter. The length of the questioned bullet is 11.9 mm, corresponding to $V = 66.6$ m/s. The diameter of the questioned bullet is 9.3 mm, corresponding to $V = 64.2$ m/s. These results are illustrated in Fig. 1.

The maximum distance (along the *x*-axis) between the least square approximation and the experimental values is a parameter that can be assimilated to the uncertainty of the method. As can be seen in Fig. 1, this uncertainty is about 5 m/s. The knowledge of the exact impact velocity is not the purpose of this study, the goal being the estimation of the shooting distance. We can nevertheless estimate it in the range 58–72 m/s, the lower value being the minimum value minus the uncertainty ($63 - 5 = 58$) and the higher value being the maximum value plus the uncertainty ($66.6 + 5 = 71.6 \sim 72$ m/s). This information is enough accurate to give a useful estimation of the shooting distance.

The impact velocity of the questioned bullet has been estimated. The corresponding shooting distance was determined in two steps. We first shot various 9 mm Parabellum round (115gr, FMJ, different cartridge manufacturers, different type of weapon) to get a statistical overview about muzzle velocity. According to our experiments, the typical muzzle velocity is 320 m/s in a compact pistol, 350 m/s in a service pistol and 400 m/s in a sub-machine gun. We then considered the muzzle velocity ranging from 320 m/s to 400 m/s.

The second step was to compute the bullet's trajectory for the considered muzzle velocities range with a commercial external ballistic software (Quickload). An example of such a curve is given in Fig. 2 (muzzle velocity: 320 m/s and 400 m/s; shooting incidence: 30°).

The shooting distance corresponding to a velocity ranging from 58 m/s to 72 m/s for both compact pistol and sub-machine gun covers approximately the range 1500–1800 m. This information demonstrated that the questioned bullet was a lost bullet.

4. Discussion

We are confident that the estimation of the impact velocity via diameter behavior is very accurate, as the measured deformation is strongly dependant on this parameter.

The corresponding shooting distance may be less accurate, due to the lack of informations about the actual muzzle velocity and ballistic coefficient. For that reason, we gave the investigator a range of shooting distance rather wide (from 1500 m to 2000 m). It is nevertheless important to notice that our experiments demonstrated that muzzle velocity is rather stable and muzzle velocity variation does not influence drastically long range velocity.

One way to estimate the accuracy of the velocity calculation would be to perform actual long range shooting. However, in the shooting range we expect to get useful informations (1500–

2000 m), ballistic experiments (especially velocity measurement) were not possible because of the excessive distance.

5. Conclusion

The interest of ballistic experiment in the field of forensic science has been demonstrated.

Experiments were quite easy to perform as the target's geometry is simple and the positioning of the impact on the target did not require any particular accuracy on the impact position and/or the incidence angle.

Estimate a long range shooting distance via ballistic experiment can be a useful tool. Simulating medium or long range shooting distance by reloading is a very interesting alternative to actual long range shooting experiments.

Acknowledgments

Authors would like to thank H. Weigel, G. D'Humieres (director and co-director of the french national institute of forensic science), G. Lancelin, P. Colas (director and co-director of the forensic science laboratory in Lille) for their support, H. Charlet and A. René Bazin de Jouy, for their helpful hand.

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