# CASE REPORT

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# The Effect of Tempered Glass on Bullet Trajectory

**REFERENCE:** Thornton, J. I. and Cashman, P. J., **"The Effect of Tempered Glass on Bullet Trajectory,"** *Journal of Forensic Sciences*, JFSCA, Vol. 31, No. 2, April 1986, pp. 743–746.

**ABSTRACT:** It was determined that tempered glass automobile windows may severely influence the trajectory of .38 Special projectiles. In replicating an actual case situation, deflections as great as 26.4° were observed with jacketed hollow-point ammunition, and as high as 10.8° for lead ammunition.

**KEYWORDS:** criminalistics, ballistics, glass

The present authors have had occasion to review the evidence in a case involving the possible deflection of a projectile by a tempered (that is, disannealed) glass automobile window. The facts in the case are essentially as follows: An altercation took place in front of a business establishment. An employee, soon to become the deceased, attempted to leave the premises in his automobile. The proprietor of the business, soon to become the defendant, emerged from the establishment and at a distance of just a few metres discharged a .38 Special revolver six times in the direction of the automobile. One projectile struck the automobile, penetrating the tempered glass window on the driver's side of the vehicle and entering the heart of the victim. The vehicle in question was a 1973 Oldsmobile Cutlass, having the side windows canted inward at an angle of 30°. This may seem to be a rather severe angle for an automobile side window, but is in fact representative of a number of vehicles manufactured in the early 1970s. The ammunition used was Smith and Wesson +P .38 Special 125-grain Jacketed Hollow Point.

The issue raised in this investigation was whether the side window of the vehicle had any significant effect upon the trajectory of the projectile. A search of the literature failed to reveal any previous work directed toward the deflection of projectiles by tempered glass intermediate targets. The 1939 work by Harper [*1*] described deflection of bullets by automobile glass, but involved only the plastic interlayer type of safety glass, and described only straight-on shots. A more recent work by Stahl et al [*2*] involved shooting through tempered glass, but was directed toward the specific area of wound ballistics and did not describe lateral bullet deflection.

Received for publication 2 April 1985; revised manuscript received 1 July 1985; accepted for publication 3 July 1985.

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A series of test firings was therefore conducted to determine the effect, if any, of an intermediate target of tempered glass on the final trajectory of a bullet. There is no particular mystery as to why this type of experiment has not been previously described; tempered glass is expensive. Unlike conventional annealed glass, tempered glass cannot be acquired in large sheets and cut up for purposes of experimentation. Each tempered glass window is manufactured as a separate unit; this is labor intensive, and consequently, tempered glass is considerably more expensive. Also, since tempered glass becomes "crazed" upon failure (that is, the glass breaks up into dice-like cubes), with the crazing extending to the edges of the pane, one cannot use a window for more than one gunshot in any series of experiments.

## Experimental Procedure

A total of 14 windows were used in the experiments. The glass was all nominal quarter-inch glass, actually measuring 5.9 mm (0.233 in.) in thickness. The glass was tilted 30° in the vertical plane and away from the weapon. A paper witness sheet was placed 100 cm behind the point of impact of the projectile on the glass. An inexpensive helium-neon laser was found to be useful for determining the "no deflection" point of impact on the witness sheet. After marking this point on the witness sheet, the laser was then removed from its support on an inexpensive optical bench and replaced with the firearm without disturbing the alignment of the system. The design of this experiment is depicted in Fig. 1. All positioning and measuring must be done before firing, since firing generally blows the window to smithereens in the immediate vicinity of the penetration.

After firing, the position of the penetration of the witness sheet by the projectile was noted. In the case of an irregular tear in the witness sheet (a frequent occurrence caused by tumbling of the projectile or separation of jacket and core), the geometrical center of the irregular tear was taken as the position of penetration. Since the hypothetical point of impact on the witness sheet (assuming no deflection) had been previously marked, the distance between this point and the actual point of impact (and penetration) represented the opposite side of a right triangle. The adjacent side was known (100 cm), and the angular deflection was thereby given by the arctangent of the opposite side over the adjacent side.

Test firing was conducted in three different series. In the first two series, jacketed hollow-point ammunition was used. In the first series, the horizontal angle of approach of the bullet was held at 90°; in the second series the horizontal angle was held at 70°. In the third series the angle of approach was again 90°, but Remington-Peters 156-grain lead ammunition was used.

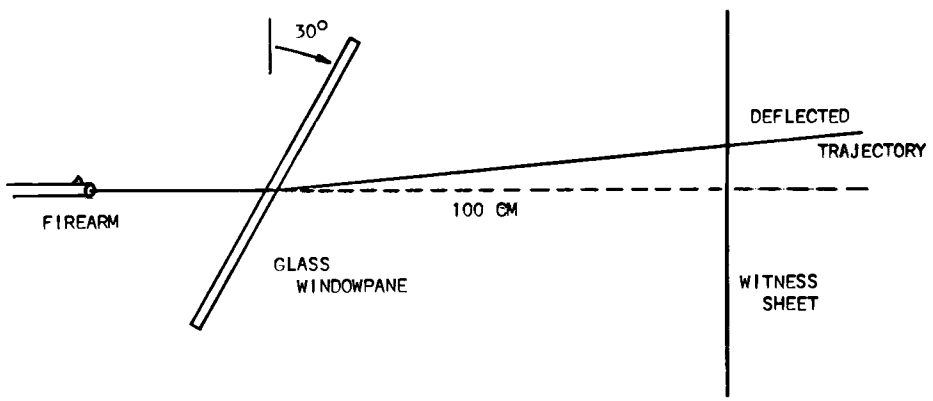


FIG. 1—*Experimental design of test firings to determine extent of projectile deflection.*

**Results and Discussion**

The results of the experimentation described above are given in Table 1. The Series One experiments (that is, the right-angle or "straight-on" approach) showed a range of deflection from 13.2 to 19.9°, with a mean of 16°. The Series Two experiments (that is, the 70° approach) showed a range of deflection from 17.8 to 26.4° with a mean of 20.5°. A *t* test was conducted to compare the difference of the mean of these two series. A statistically significant difference at an alpha value of 0.05 (two-tailed) was found, indicating that the horizontal angle of approach is indeed a factor in the deflection of the projectile by the window. In the two series involving jacketed hollow-point ammunition, separation of the jacket and core was noted in approximately half the test shots. (The core penetration on the witness sheet was distinguished from the jacket penetration by the conspicious presence of a lead wipe.) The third series of experiments, using lead ammunition, was therefore conducted to test the hypothesis that deflection might be greater if separation takes place (because of the loss of stability in flight resulting from the inevitable eccentricity caused by separation of the jacket and core). The mean of the deflection of the lead projectile was found to be 10.7°. A two-tailed *t* test determined that the mean of the Series Three tests was statistically different at an alpha value of 0.05 from the mean of the Series One tests.

TABLE 1—*Angular deflection of .38 Special ammunition by 5.9 mm (0.233 in.) thick tempered glass automobile windows at selected angles of approach. J/C—jacket and core apparently together, J—separated jacket, and C—separated core.*

| | Deflection, in degrees | | |
|---|---|---|---|
| Test | J/C[a] | J | C |
| | SERIES ONE[b] | | |
| Shot 1 | 13.2 | | |
| 2 | | 19.8 | 17.6 |
| 3 | 15.2 | | |
| 4 | | 17.1 | 15.3 |
| 5 | | 19.9 | 17.9 |
| 6 | 15.4 | | |
| 7 | 13.3 | | |
| 8 | | 16.3 | 16.2 |
| | SERIES TWO[c] | | |
| Shot 9 | | 26.4 | 20.1 |
| 10 | | 19.8 | 17.8 |
| 11 | 18.6 | | |
| | SERIES THREE[d] | | |
| Shot 12 | 9.9 | | |
| 13 | 11.4 | | |
| 14 | 10.8 | | |

[a]Including, in the case of Series Three, the unjacketed lead projectile.

[b]Jacketed Hollow-Point ammunition; angle of approach 90°, that is, "straight-on" shots.

[c]Jacketed Hollow-Point ammunition; angle of approach 70°, that is, shots approaching the glass from the right side at angle of 20° from the perpendicular.

[d]Lead ammunition; angle of approach 90°.

On the basis of the foregoing, it is concluded that tempered glass does in fact affect bullet trajectory profoundly, particularly when the glass is at an angle to the line of fire and when jacketed hollow-point ammunition is used. The significance of this finding to the case in point is that from the standpoint of the trajectory alone, if the defendant had wanted to shoot the victim in the heart, he would have had to have aimed elsewhere. If he had been aiming at the victim's heart, he would have either missed him or hit him somewhere else. The defendant was convicted of manslaughter.

The writers wish to stress that the present experiments are relevant only to *handgun* ammunition. High velocity, high kinetic energy projectiles characteristic of centerfire rifle ammunition may not display much deflection. A very limited experiment with two tempered glass windows showed little or no deflection of 7-mm Mauser Ball projectiles.

## References

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