B39 The Determination of Critical Angle in Automobile Windshield Glass Using 9mm Luger® Ammunition

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After attending this presentation, attendees will better understand the characteristics of automobile windshield glass and how it reacts to bullet impacts. Attendees will also be aware of the type of ammunition used in these experiments and the factors influencing bullet perforation or bullet ricochet off a windshield.

This presentation will impact the forensic science community by exploring the angle necessary for a bullet to perforate or ricochet after impacting a windshield, which has implications in examining a shooting scene involving an automobile.

An understanding of bullet ricochet is a vital part of deconstructing shooting scenes; however, a bullet's ricochet depends on many factors, the totality of which may not be replicated from one scenario to the next. This presentation deals with bullet ricochet off windshield glass. All variables were held constant with the exception of incident angle, which is the angle at which a projectile impacts the target surface. The angle at which the projectile leaves the substrate is the ricochet angle. When a bullet strikes a target, it may perforate or penetrate the substance, fragment into pieces or ricochet off the surface. Ricochet is the change in direction of a bullet's trajectory after impact with a surface. Each surface has an angle called the critical angle, below which a projectile will ricochet. The critical angle is dependent upon each type of surface. The inability to generalize is due to the fact that there are many factors that affect the ricochet of a bullet, such as incident angle, impact velocity, bullet shape, bullet weight, bullet hardness, bullet center of gravity, the hardness of the impact surface, and the response of that surface to the bullet's impact. It is important to note that not only do the characteristics of the bullet have an effect on the ricochet, characteristics of the impact surface do as well. Both need to be analyzed in cases of ricochet.

Laminated glass, which is used on automobile windshields, is composed of a thin polyvinyl plastic layer sandwiched between two pieces of glass. The glass is bonded to the plastic by heat and pressure. The layers are then secured to the auto with a gasket material. This type of glass is the strongest available for its particular thickness of glass according to the National Glass Association.[1] It is also more resistant to shattering because the plastic middle layer will remain bound to glass pieces that have been broken. This prevents the glass from breaking up into large sharp pieces after impact. In the United States, laminated glass must be installed in the windshields of vehicles while tempered glass is required in the side and rear windows according to the United States Department of Transportation.[2]

Because there are many variables associated with bullet ricochet in general and specifically with windshield glass, the firearm, ammunition, and substrate were kept consistent throughout the course of the experiments. This study used 9mm Luger® ammunition with a Full Metal Jacket (FMJ) bullet. According to the manufacturer, the muzzle velocity is 1,150 feet per second, which was confirmed using a chronograph to determine the velocity of the specific lot of ammunition used.

Initial test shots at 5°, 10°, and 20° incident angles were performed to determine the effect the bullet had on the windshield. Five degrees yielded a clean ricochet with minimal damage to the windshield and a fairly intact bullet. This was not the case with 20°, where the bullet perforated the windshield. High-speed photography elucidated

the mechanism of the bullet-glass interaction. Shots fired at 10° resulted in a ricocheted bullet that retained a substantial portion of its initial mass. Ten degrees was then bracketed by shots at 9° and 11° to compare the damage caused by the bullet and the associated damage caused to the bullet. A system was devised to capture and recover bullet fragments from both the surface of the windshield and from underneath the windshield, which was used to determine the percent of post-ricochet weight loss. Witness papers were used downrange to determine the ricochet angle using trigonometry. Incident angles of 5°, 10°, and 20° had ricochet angles of 3°, 8°, and 15°, respectively.

Reference(s):

1. Industry Resources. Ask the Expert. Retrieved 30 July 2016 from https://glass.org/industry-resources-ask-the-expert-faq.html.
2. Code of Federal Regulations (CFR). *Federal Motor Vehicle Safety Standards, Glazing and Window Construction.* 49 CFR 571,205, 1972.

Ricochet, Windshield, Critical Angle