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223 Remington Barnes 55gr Triple-Shock

Ballistic Equivalency in 10-percent gelatin, 20-percent gelatin and Clear Ballistics™ ballistic gelatin

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April 19, 2013

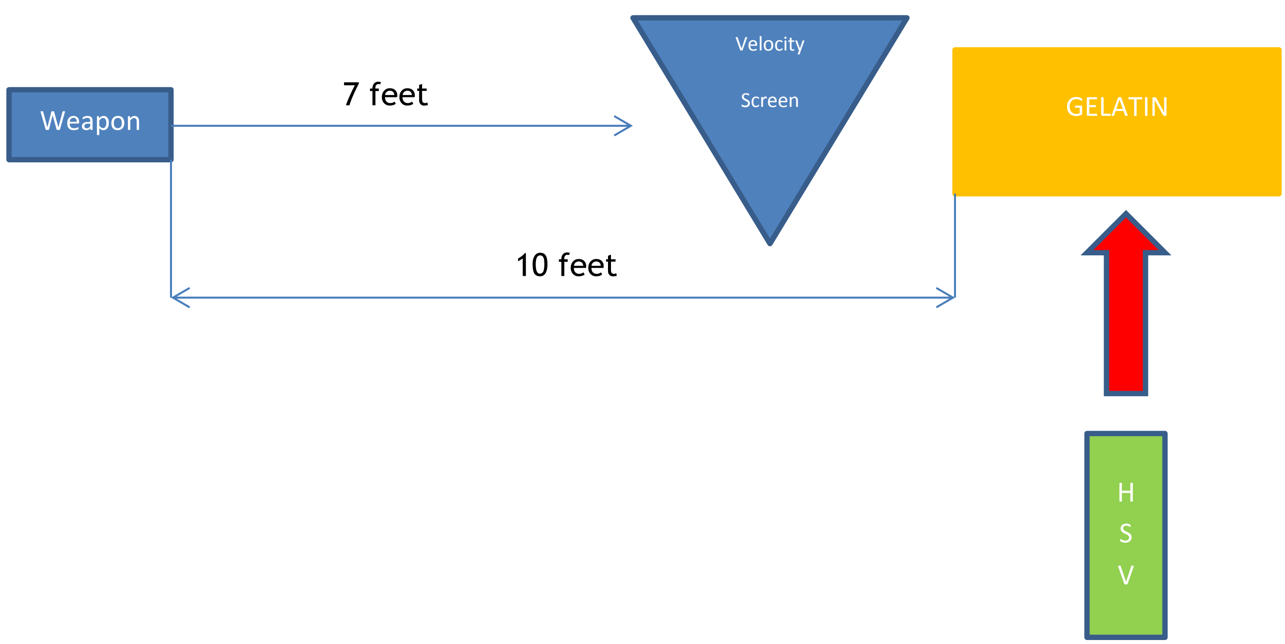
Introduction

We tested 223 Remington Federal Premium Barnes 55gr Triple-Shock ammunition against blocks of calibrated 10-percent ballistic gelatin, 20-percent ballistic gelatin and Clear Ballistics™ brand ballistic gelatin. All shots were fired from 10ft distance between the front face of the ballistic gelatin block and the muzzle of an AR-15 with 20.0" barrel length and 1/12" rifling twist.

Ballistic gelatin blocks are distinguished by the concentration of ballistic gelatin powder that is dissolved in the water. For example, a 10-percent gelatin block made to FBI-specification size for handgun testing uses 1kg of ballistic gelatin powder and 9kg of water. Ballistic gelatin powder is of course what holds the water in a solid shape and is what gives the gelatin block greater viscosity as the bullet nears the end of its penetration track and comes to a rest.

Of interest was measuring the 'ballistic equivalency' between the three different ballistic mediums to establish the similarities and differences that may exist and influence observed bullet terminal behavior. It should be stressed that handgun, shotgun and larger-caliber rifle projectiles will exhibit different fluid dynamic behavior so **the results below are valid only for projectiles that impact at 3000 ft/sec impact velocity and have a frontal surface area of approximately 0.130in^2.**

Figure 1. Test site setup diagram (overhead view)



Results

Figure 2. Barnes 55gr TSX impacting 10-percent ballistic gelatin

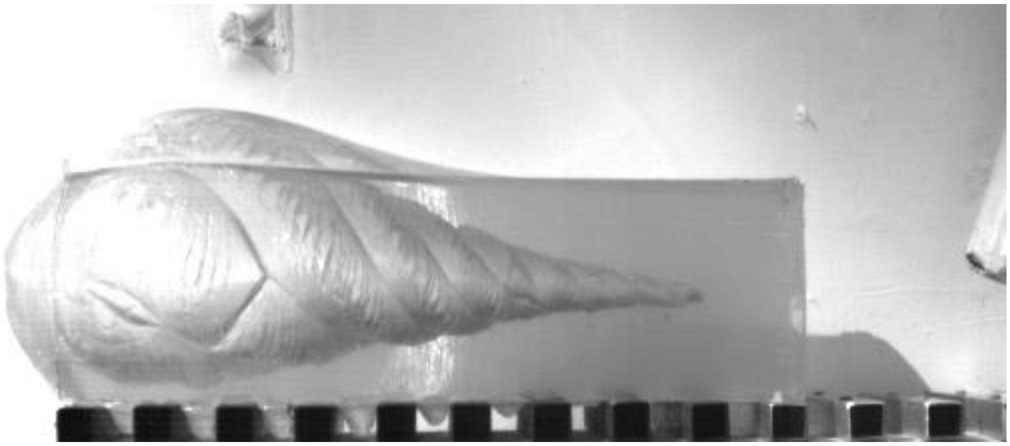


Figure 3. Barnes 55gr TSX impacting 20-percent ballistic gelatin

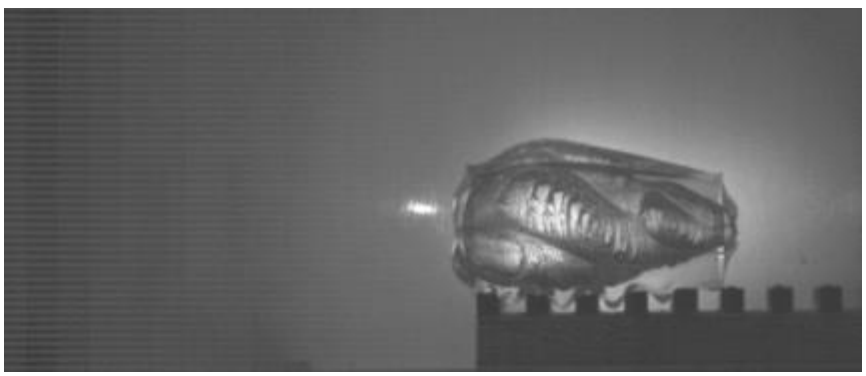
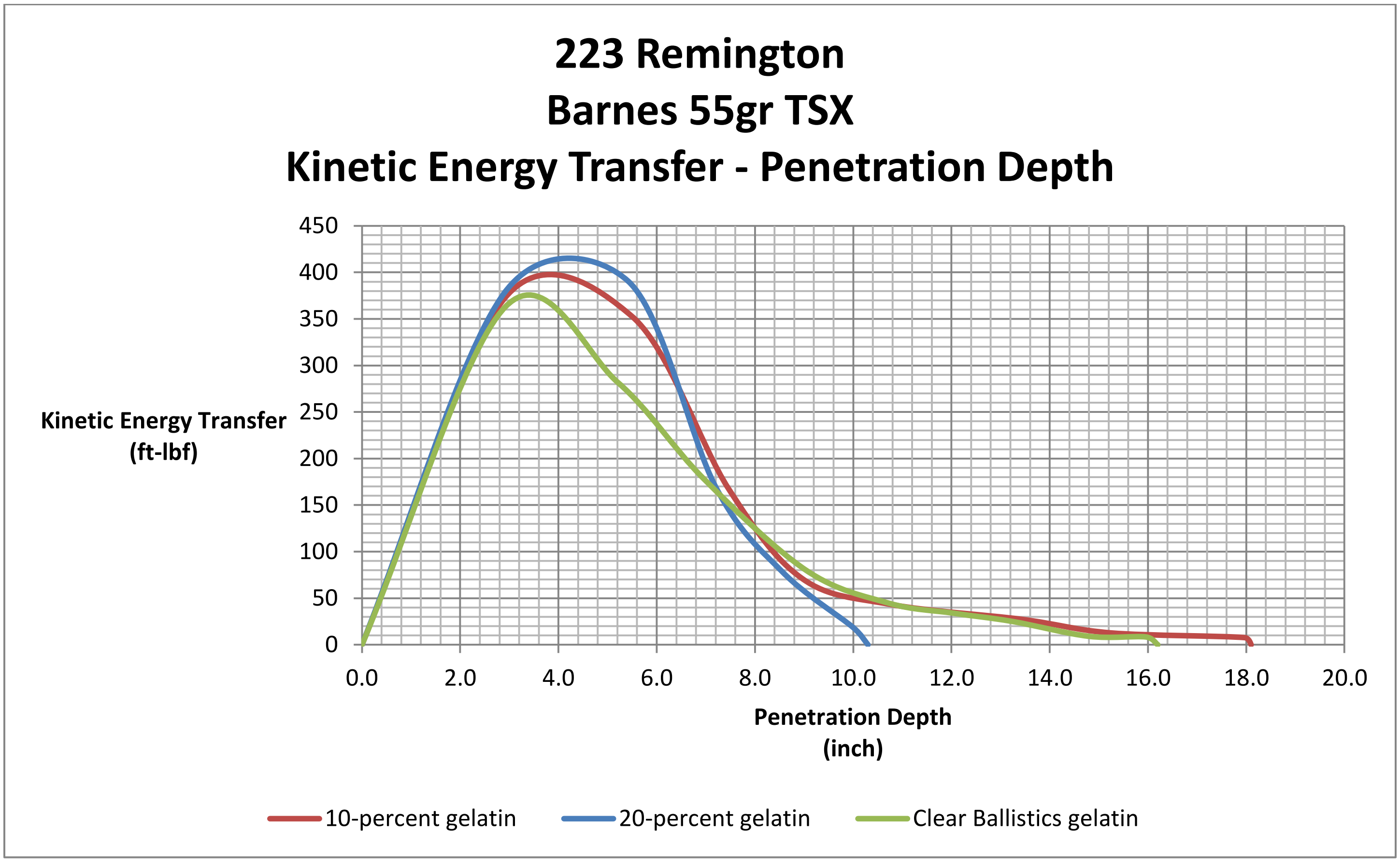


Figure 4. Barnes 55gr TSX impacting Clear Ballistics™ ballistic gelatin

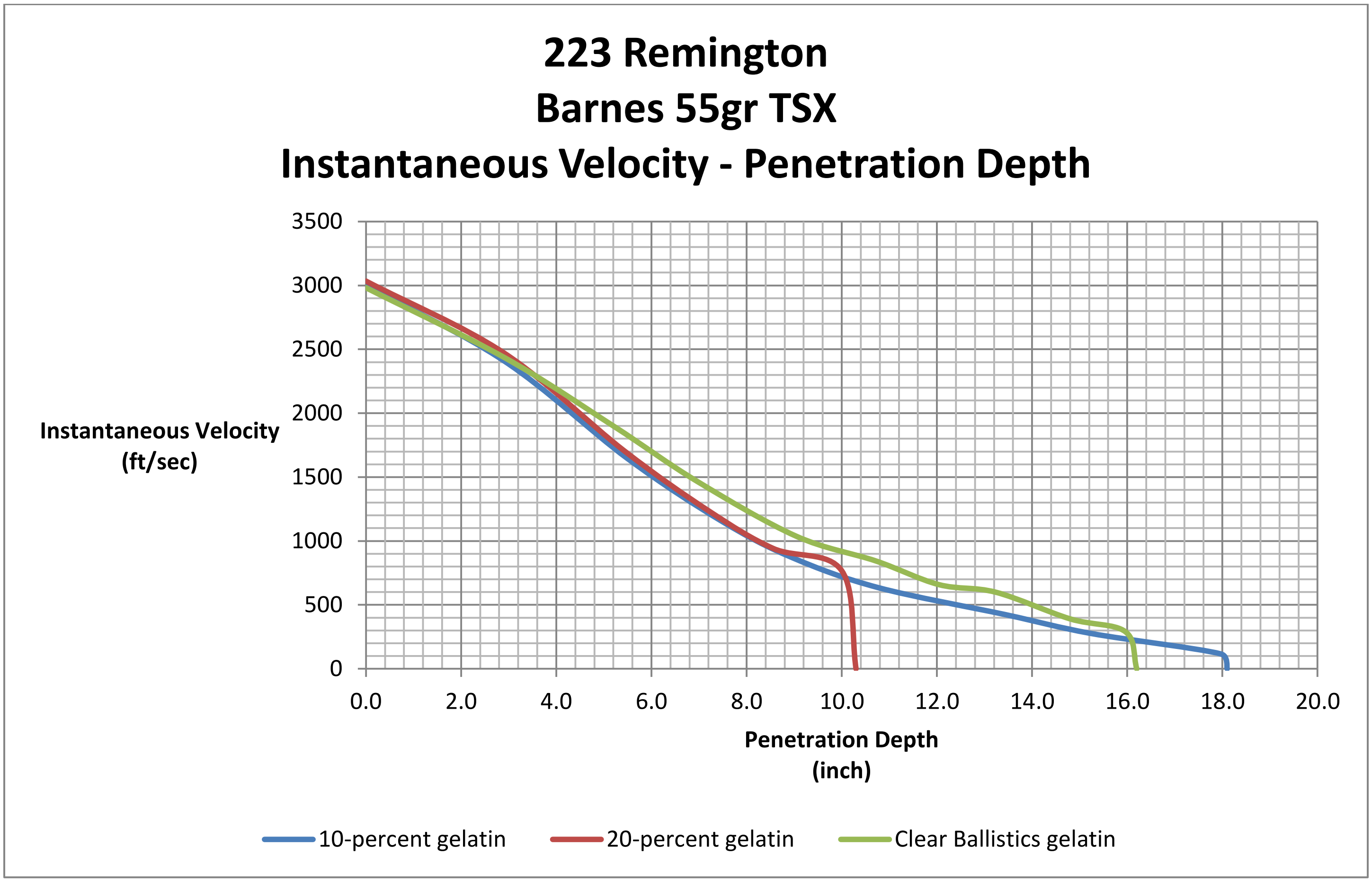
Figure 5. Kinetic Energy transfer of Barnes 55gr TSX bullet through the three mediums



We see that the 20-percent ballistic gelatin offers the greatest initial resistance to bullet penetration, followed by the 10-percent and then the Clear Ballistics™ gelatin. One of the properties of 20-percent gelatin is significant kinematic viscosity at lower projectile velocities. This is illustrated clearly at 7.2-10.3 inches penetration depth with the rapid drop-off in kinetic energy transfer per unit of penetration depth. Contrast this to the performances of the bullet in 10-percent gelatin and Clear Ballistics™ gelatin where the 'waterfall' shape of the plot in Figure 5 ends abruptly at 9.2 inches and continues steeply horizontal until the projectiles come to rest at 18.1 inches and 16.1 inches respectively.

The longer 'low velocity' wound track in 10-percent and Clear Ballistics™ gelatin is beneficial to the home experimenter or those without access to sophisticated slow motion video cameras suitable for terminal ballistics testing. This is because the greater penetration depth afforded by the lower kinematic viscosity allows for higher fidelity of measurement with a ruler or similar easily-purchased measuring device. Put simply, larger measurements allow for more measurement error without significantly affecting the quality of the data recorded. A ballistics experimenter at home would be most likely to measure the penetration depth of a bullet by placing a ruler on top of the gelatin block. This is a convenient and fast way to measure but introduces measurement error through the diffraction of the medium and the subjectivity of the observer in finding the leading edge of the bullet. These deeper penetration depths help to reduce the effect of these errors on the quality of the data gathering.

Figure 6. Instantaneous Velocity of Barnes 55gr TSX bullet through the three mediums



Ballistic gelatin is a fluid medium known as a *solid liquid* which is a solid at rest but behaves as a liquid when impacted by a projectile in motion. Damage done by a bullet in a fluid medium can be considered as being the opposite of the drag force, which is measurable by tracking the bullets velocity drop as it moves through the target. The drag force acting on a penetrating object is:

$$F_D = \frac{1}{2}\rho v^2 C_D A$$

Where F is the fluid drag force, ρ is the density of the fluid medium, v is the velocity of the penetrating object, C_D is the drag coefficient and A is the frontal surface area of the penetrating object. The variables are the impact velocity of the bullet, density of the block and the drag coefficient of the bullet. Because all shots were fired out of the same firearm using the same lot of ammunition at the same distance we can assume that the angle of attack, bullet expansion and impact velocities are very similar so the coefficient of drag will also be similar.

Since the velocity of the tested bullets were closely the same at the first measurement depth, the cross-sectional areas are closely the same and the drag coefficients are assumed to be closely the same, we look to the density of the different gelatin types as the driving factor in the differences in measured bullet terminal performance.

Expanding ammunition relies on the phenomenon of *stagnation pressure* in order to start expansion of the bullet nose. Stagnation pressure is defined as:

$$P_{\text{total}} = \tfrac{1}{2}\rho v^2 + P_{\text{static}}$$

Where ρ is the density of the fluid, v is the velocity of the bullet at any instant and P_{static} is the static pressure of the fluid. The stagnation pressure acting on a bullet impacting a ballistic gelatin block is influenced only by the velocity the bullet impacts at, since the density of a proper ballistic gelatin block does not change significantly. Static pressure is also considered constant because it is determined by the weight of the gelatin above the bullet as it penetrates and this is insignificant compared to the pressure present on the face of a bullet as it penetrates.

Table 1. Density and Maximum Stagnation Pressure of the three ballistic mediums

Material	Density (kg/m^3)	Stagnation Pressure (PSI)
10 Percent ballistic gelatin	1025	62,069
20 Percent ballistic gelatin	1048	64,999
Clear Ballistics™ gelatin	824	49,364

We see from Table 1 that the average stagnation pressure seen by bullets shot into the porcine-based ballistic gelatin is 1.29 times higher than that experienced in the Clear Ballistics™ gelatin block. This influences the magnitude of bullet expansion and thusly the frontal surface area in the drag equation.

For the readers convenience the drag equation is printed again below:

$$F_D = \tfrac{1}{2}\rho v^2 C_D A$$

The drag force acting on the bullet is reduced by the reduced density of the Clear Ballistics™ gelatin block and indirectly affected by the reduced frontal surface area caused by the lower stagnation pressure incident on the face of the bullet. This accounts for the apparently lesser damage caused until the transition to ‘low velocity flow’ at 9.2 inches depth.

Summary

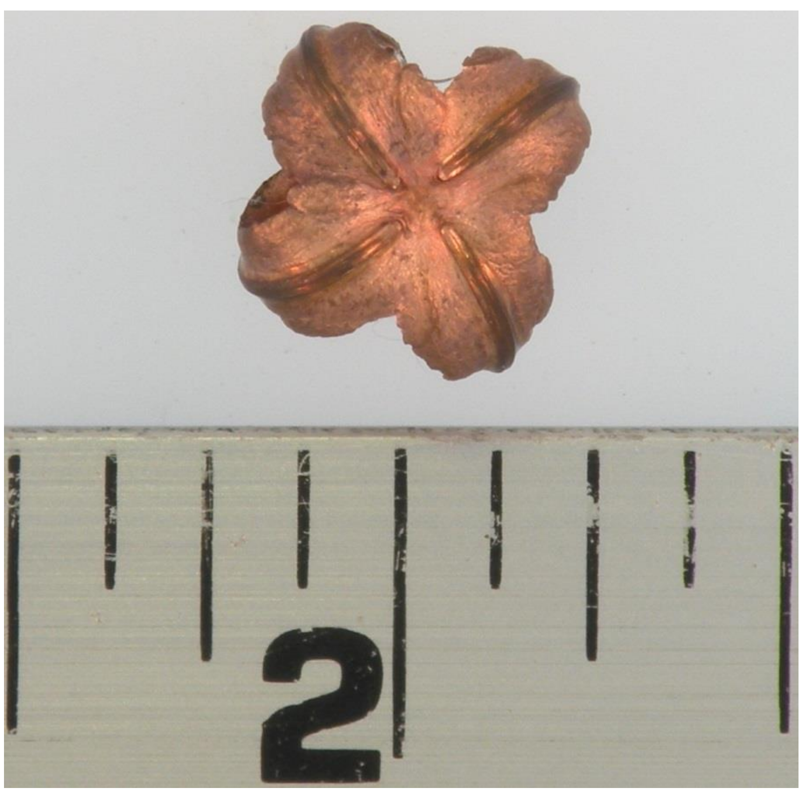
20-percent ballistic gelatin has great historical, current and international presence as a medium for terminal ballistics evaluations. Ballistic gelatin blocks with a concentration of 10-percent ballistic gelatin are a relative newcomer, having been in common usage since the 1980s. The Clear Ballistics™ gelatin block is a replacement material for porcine-based ballistic gelatin and offers many significant advantages in usability, including no need for refrigeration and the ability to be re-melted and re-shot repeatedly.

If the experimenter has a budget for a high speed video camera (often costing in excess of 100,000 US Dollars (2010 USD)) the 20-percent gelatin is good as it allows for the results to be compared to historical and current data published by the US government and other world military powers. Were a statistically-sound table of correlations to be established to convert results obtained in 10-percent gelatin blocks to those obtained in Clear Ballistics™ gelatin blocks, we would unequivocally recommend the Clear Ballistics™ material for hobbyist and small-scale industrial testing of small arms ammunition due to its ease of use and lower average material cost when compared to 10-percent ballistic gelatin blocks.

Appendix

A1. 223 Remington Barnes 55gr TSX bullet recovered from 10-percent ballistic gelatin

A2. 223 Remington Barnes 55gr TSX bullet recovered from 20-percent ballistic gelatin



A3. 223 Remington Barnes 55gr TSX bullet recovered from Clear Ballistics™ ballistic gelatin