A terminal ballistics comparison of 9mm Luger and 45 Auto ammunition

9mm Luger has seen a huge increase in popularity over the last decade. Justification for how a previously ‘anemic’ self-defense round is now optimum includes the following: “new bullet advancements”, “modern bullet designs”, and so on. This is said to convince the listener that 9mm Luger is no longer anemic but also equivalent to the terminal performance of never-questioned cartridges like 40 S&W and 45 Auto.

If these ‘new bullet advancements’ can be applied to 9mm, it can be applied to other bullets. The idea of a new technology being implemented in jacketed hollowpoints is often parroted but never substantiated. The lethality difference between pistol cartridges is significant enough to influence firearm selection but there is no hardware substitute for a determined and trained shooter. A shooter is legally liable for every bullet they send downrange. Criminals are sneaky by nature and will attempt through surprise to take away your ability to react. If you could only get one mediocre shot on an attacker before they are on top of you, which cartridge would you carry?

650 jacketed hollowpoints were shot into ballistic gelatin from 9mm Luger and 45 Auto firearms for this blog post. Comparison of the two cartridges using permanent cavity diameter, kinetic energy transfer, performance against bone and FBI barrier test performance are presented in this report.

BARE GELATIN TERMINAL PERFORMANCE

Cartridge	Velocity ($^{ft}/_{sec}$)	Penetration (inch)	Expansion (inch)	Weight (grain)	Kinetic Energy (ft-lbf)
9mm Luger Federal HST 124gr	1130	10.7	0.62	124	350
45 Auto Federal HST 230gr	910	11.7	0.81	219	400
9mm Luger +P Hornady AG XTP 124gr	1130	12.5	0.54	115	330
45 Auto +P Hornady XTP 230gr	910	12.9	0.69	230	430
9mm Luger Remington GS 124gr	1110	12.4	0.58	124	340
45 Auto Remington GS 230gr	810	13.3	0.68	230	340
9mm Luger Speer Gold Dot 124gr	1120	11.8	0.58	124	350
45 Auto Speer Gold Dot 230gr	820	11.7	0.68	230	340
9mm Luger +P Winchester Ranger-T 124gr	1180	10.5	0.59	115	360
45 Auto Winchester Ranger-T 230gr	890	12.2	0.75	230	410
9mm Luger FMJ 115gr	1190	25.5	0.36	115	360
45 Auto FMJ 230gr	830	30.4	0.45	230	350
9mm Luger 124gr JHP Average	**1130**	**11.8**	**0.57**	**121**	**350**
45 Auto 230gr JHP Average	**860**	**12.1**	**0.71**	**228**	**370**

The above are 5-shot averages from a 4″ long 9mm Luger barrel and a 5″ long 45 Auto barrel. SAAMI ammunition manufacturers use these barrel lengths to control production. Bullet expansion is a key component in wounding. The 9mm Luger bullets expanded to 0.57″ and the 45 Auto bullets expanded to 0.71″ – 25% greater diameter. There is a correlation between bullet diameter and the diameter of the hole made by a bullet in ballistic gelatin. The larger the bullet, the larger the hole. Larger holes bleed more because there is less resistance to fluid flow through a larger 'pipe.' The more rapid the blood loss, the more quickly an attacker is stopped.

Much is made about bullet velocity as a wounding factor. Higher velocity does not equate to larger hole size at pistol velocity. In testing, a 9mm Luger Speer Gold Dot 124gr at 1100 $^{ft}/_{sec}$ expanded to the same diameter as a 357 SIG Gold Dot 125gr at 1400 $^{ft}/_{sec}$ and both made the same size hole. Permanent cavity ('hole size') can be compared by pulling a rod with a sphere attached at the end through a gelatin block. The force required to pull the sphere through is measured with a force gauge attached to a motorized test stand.

Mark-10 test stand model used in the testing

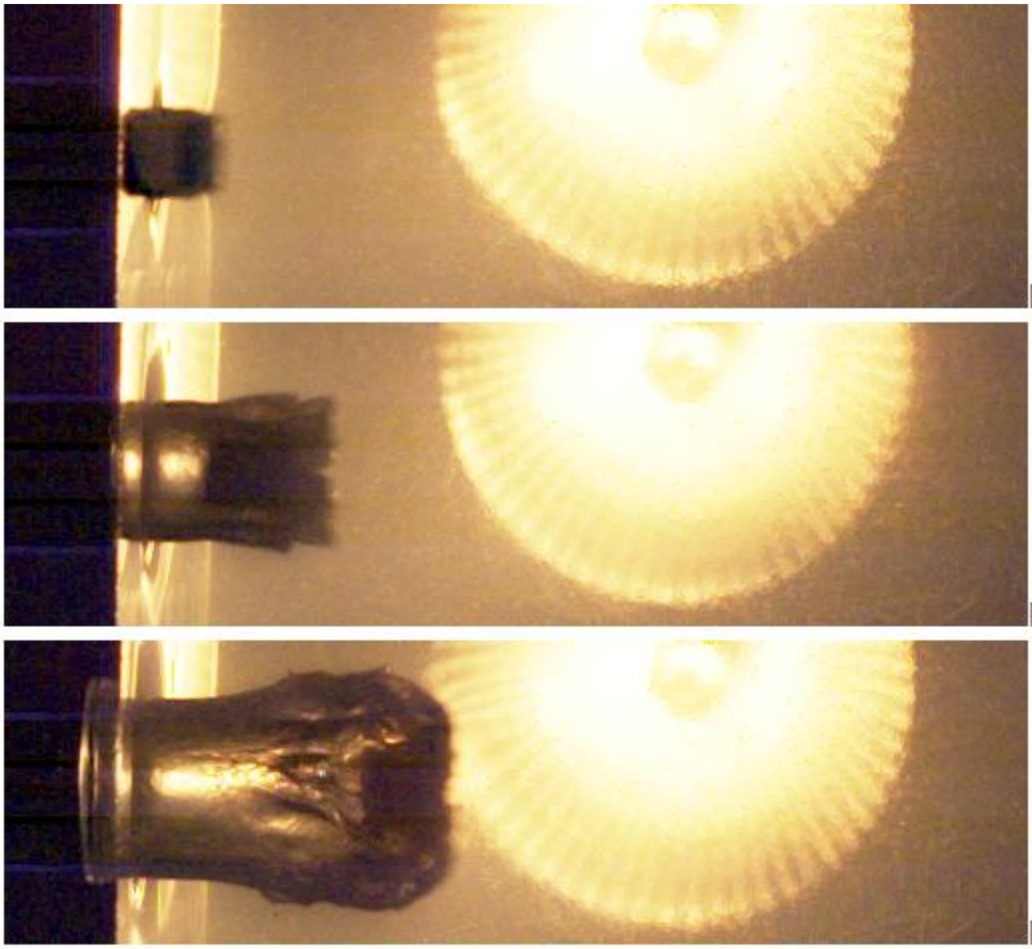
Sphere and rod being pulled through the gelatin wound track (sphere circled)

The larger the hole made by the bullet, the easier the sphere can be pulled through so the force seen by the gauge will be lower. Five Federal 9mm Luger +P HST 124gr and five Federal 45 Auto +P HST 230gr bullets were shot into bare gelatin. It took 0.30 pounds of force to pull the sphere through the 9mm track and 0.26 pounds to pull the sphere through the 45 Auto track. Because the force required to pull the sphere through was lower, its logical that the 45 Auto made a bigger hole.

Permanent cavity diameter is measured by casting rods of known diameter into gelatin blocks, removing the rods and pulling the sphere through the known-diameter hole. This is the correlation between force and hole diameter. In the above testing, the 9mm made a 0.090” diameter hole and the 45 Auto made a 0.114” diameter hole through the gelatin block. 45 Auto was a 27% increase in bullet hole diameter over 9mm. The 9mm bullets expanded to 0.57” diameter and the 45 Auto expanded to 0.72”. 45 Auto expansion is 25% greater than 9mm Luger. 27% and 25% lining up this well is not a coincidence. Permanent cavity diameter tracked well with expanded diameter despite 9mm Luger traveling 31% faster than 45 Auto.

KINETIC ENERGY TRANSFER

Since the appearance of the FBI 12” minimum gelatin penetration depth in the mid-1980s, there has been a steady skewing and confounding of thought regarding kinetic energy transfer and its role in terminal performance. An object in motion has kinetic energy. Energy is needed to force a bullet through tissue. Kinetic energy transfer is a method of accounting for this energy input and where in the gelatin block it occurred. The more kinetic energy a bullet loses, the more damage can be done to the target. Energy is transferred pushing tissue apart, making a hole. Critics of kinetic energy transfer correctly assert that temporary cavity from a handgun is not a significant wounding factor. This is because most organs are elastic and will spring back minimally harmed after the passage of a bullet.



Bullet impact

Expansion begins (at 0.5”)

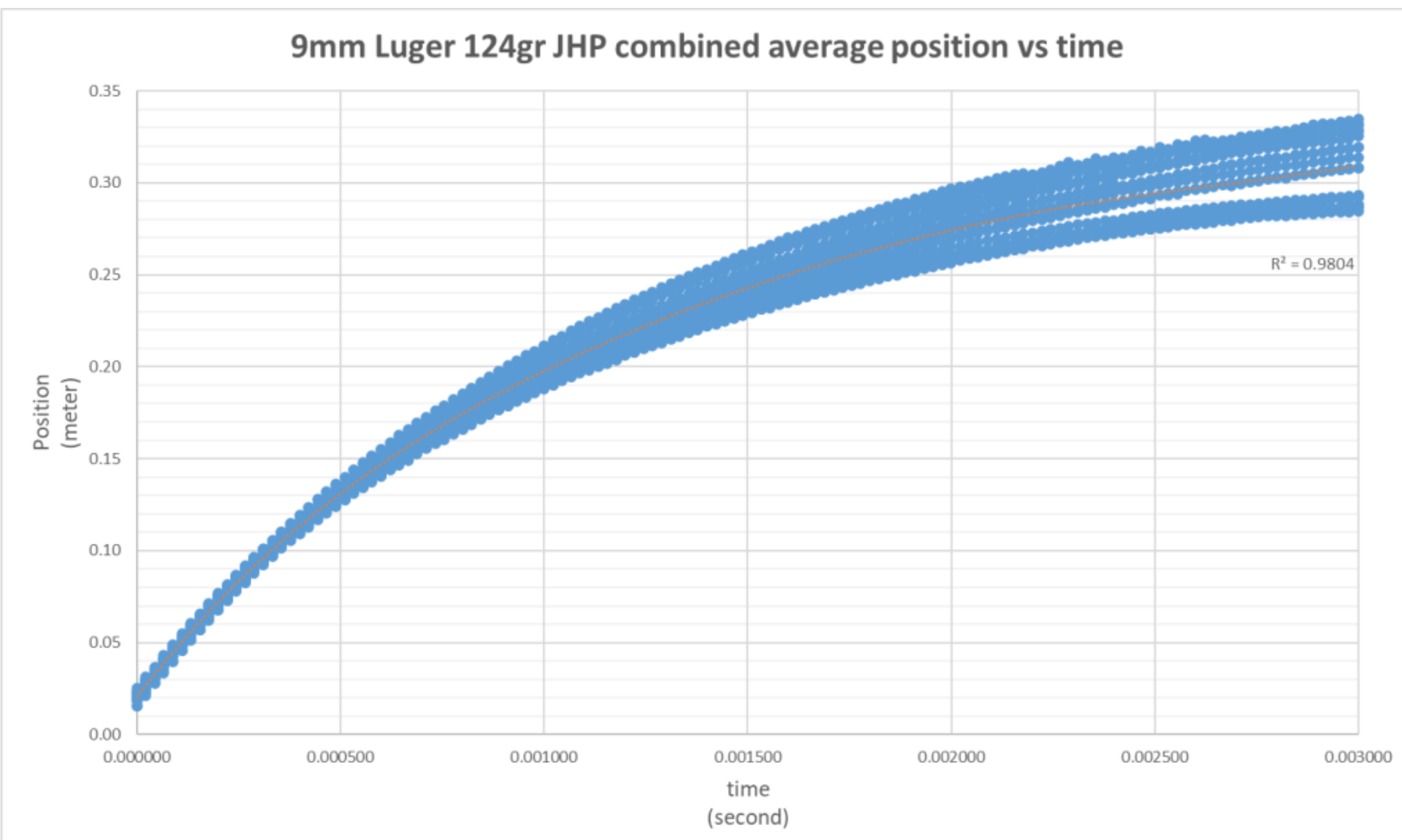
Full expansion (at 1.0”)

Speer 9mm Luger Gold Dot 124gr expansion

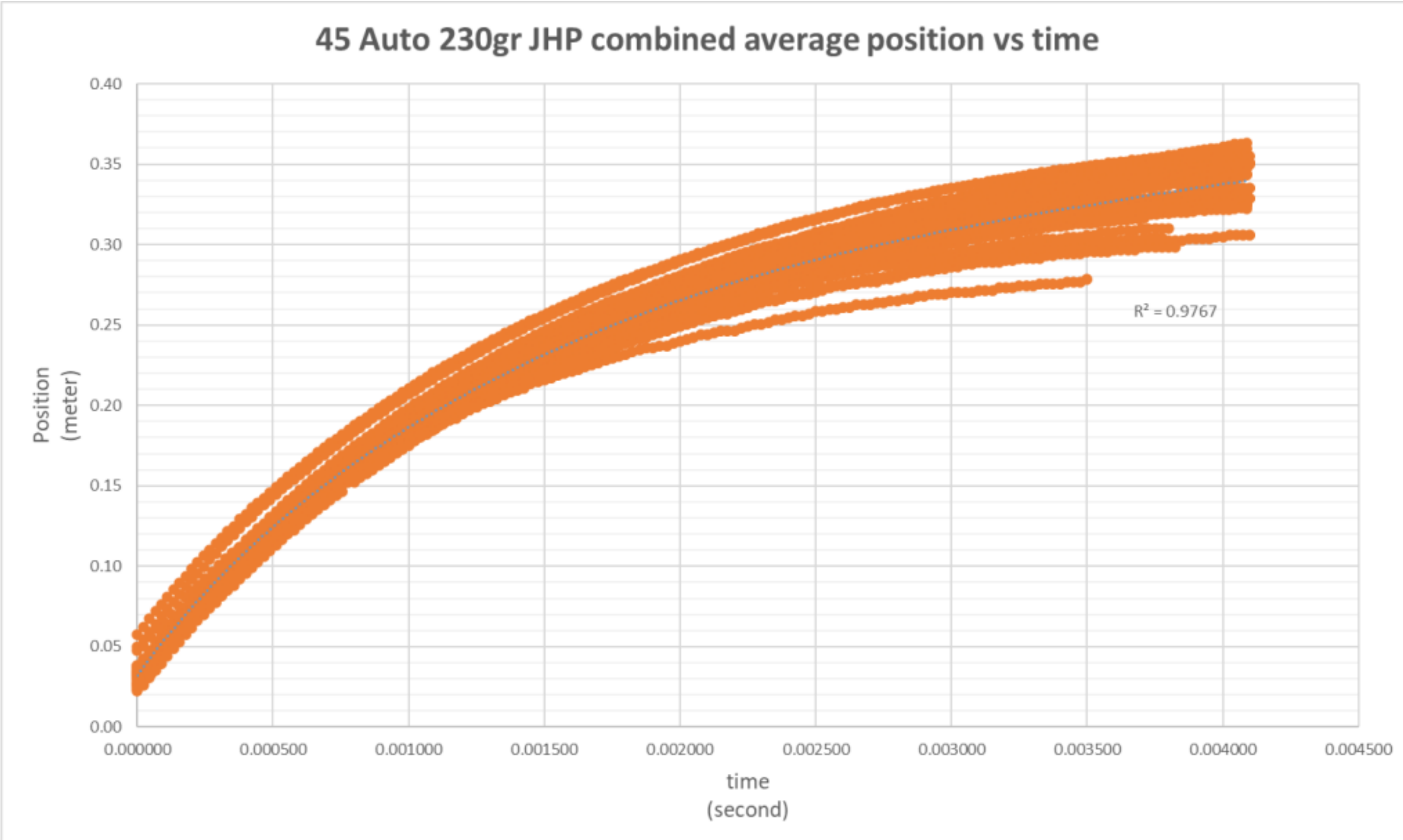
The above images are of the stages of hollowpoint expansion. A hollowpoint must penetrate up to the depth of its cavity before expansion starts. Expansion occurs very rapidly thereafter as the jacket segments fold back due to pressure exerted by the moving fluid. A hollowpoint cannot continue to expand beyond 1.5” penetration.

Vision Research Phantom v711 high speed camera

A Vision Research Phantom v711 high speed camera was used to get time and position data of the bullets moving through gelatin blocks. Each data point represents penetration depth of the bullet every 22 microseconds that the bullet was moving through gelatin. 3840 data points for bullet position versus time was obtained for the 9mm Luger JHPs.



45 Auto is a slower moving bullet so it gives more data points. 6620 data points of position vs time were obtained for the 45 Auto JHP bullets.



Here are two frames from the same high speed video to illustrate how kinetic energy transfer is calculated.

This is a Winchester 45 Auto Ranger-T 230gr bullet at 2.87" into the gelatin block. It has taken 0.000289 seconds for the bullet to travel this far from the point of impact. In the interest of demonstrating this concept, the average velocity of the bullet between these two points is 2.87 inches divided by 0.000289 seconds = 9931 $^{inch}/_{sec}$ = 828 $^{ft}/_{sec}$. These bullets weighed 230gr after being pulled from the gelatin block, washed and then dried.

Kinetic energy is calculated using this formula:

KE = (velocity^2 * bullet weight) / (450240)
KE = (828 * 828 * 230) / (450240) = 350 ft-lbf

This is the same bullet at 5.16" into the gelatin block. It has taken 0.000311 seconds to travel 2.29" further into the gelatin block. In the interest of demonstrating this concept, the average velocity of the bullet between these two points is 2.29 inches divided by 0.000311 seconds = 7363 $^{inch}/_{sec}$ = 614 $^{ft}/_{sec}$. Which corresponds to a kinetic energy of:

KE = (614 * 614 * 230) / (450240) = 193 ft-lbf

Between 2.87" and 5.16" penetration depth, this bullet transferred 350 – 193 = 157 ft-lbf kinetic energy to the gelatin. For reference, this is enough energy to lift a 157 pound object 1 foot upwards.

This is the logic of calculating kinetic energy transfer of a bullet. The actual velocity of the bullet is calculated using the trendline (visible in the above two graphs) and derivative calculus. This produces the most accurate results. The derivative method is used in all calculations in this report.

Validation of results

Oehler 57 velocity screens were placed at 20ft distance from the muzzle of a SAAMI accuracy barrel to validate the method used with the high speed camera to produce the kinetic energy transfer data. Muzzle velocities were recorded for verification, ballistic gelatin blocks of nominal 3" thickness were placed in front of the velocity screens and the velocity of the expanded JHP as it exited each gelatin block was recorded.

Cartridge	Penetration (inch)	Oehler 57 velocity ($^{ft}/_{sec}$)	Phantom v711 velocity ($^{ft}/_{sec}$)	% Difference
9mm Luger Remington GS 124gr	3.0	775	771	1
45 Auto Remington GS 230gr	3.0	543	589	8
9mm Luger Speer Gold Dot 124gr	3.6	659	669	2
45 Auto Speer Gold Dot 230gr	2.8	581	604	4
9mm Luger Winchester Rng-T 124gr	2.8	753	770	2
45 Auto Winchester Ranger-T 230gr	3.0	562	661	16
9mm Luger FMJ 115gr	3.0	1098	1082	1
45 Auto FMJ 230gr	3.0	757	785	4

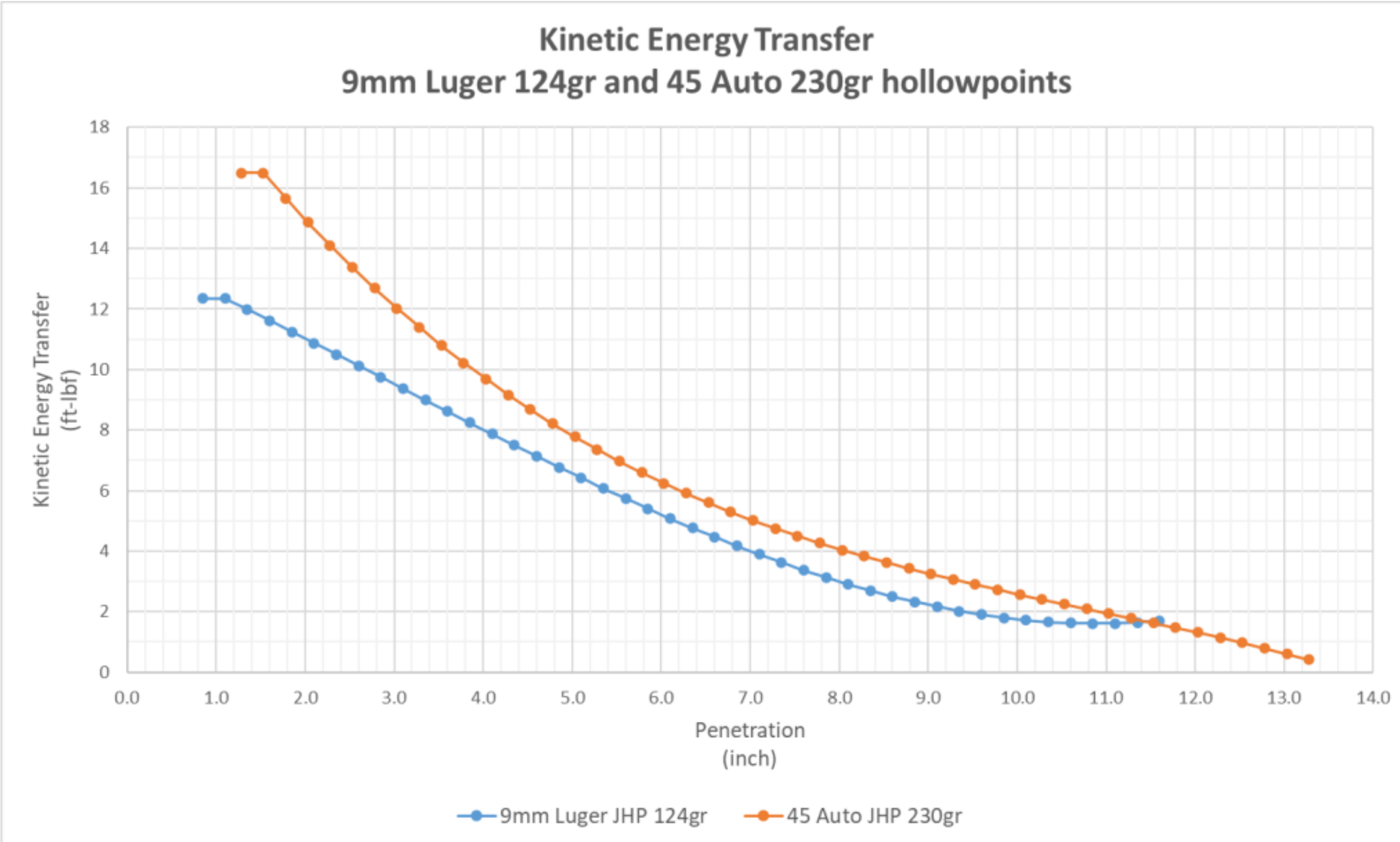
The 16% error on the 45 Auto Winchester Ranger-T is reasonably attributable to the significant inconsistency of expansion observed from this lot. The expansion of these bullets ranged from 0.70 - 0.74” and there was one complete failure to expand in the 10-shot data set.

Cartridge	Penetration (inch)	Oehler 57 velocity ($^{ft}/_{sec}$)	Phantom v711 velocity ($^{ft}/_{sec}$)	% Difference
9mm Luger Remington GS 124gr	1.8	895	877	2
9mm Luger Remington GS 124gr	3.8	687	712	4
9mm Luger Remington GS 124gr	6.2	486	528	7

9mm Luger Remington Golden Saber 124gr at 1094 $^{ft}/_{sec}$ vs. gelatin of various thickness

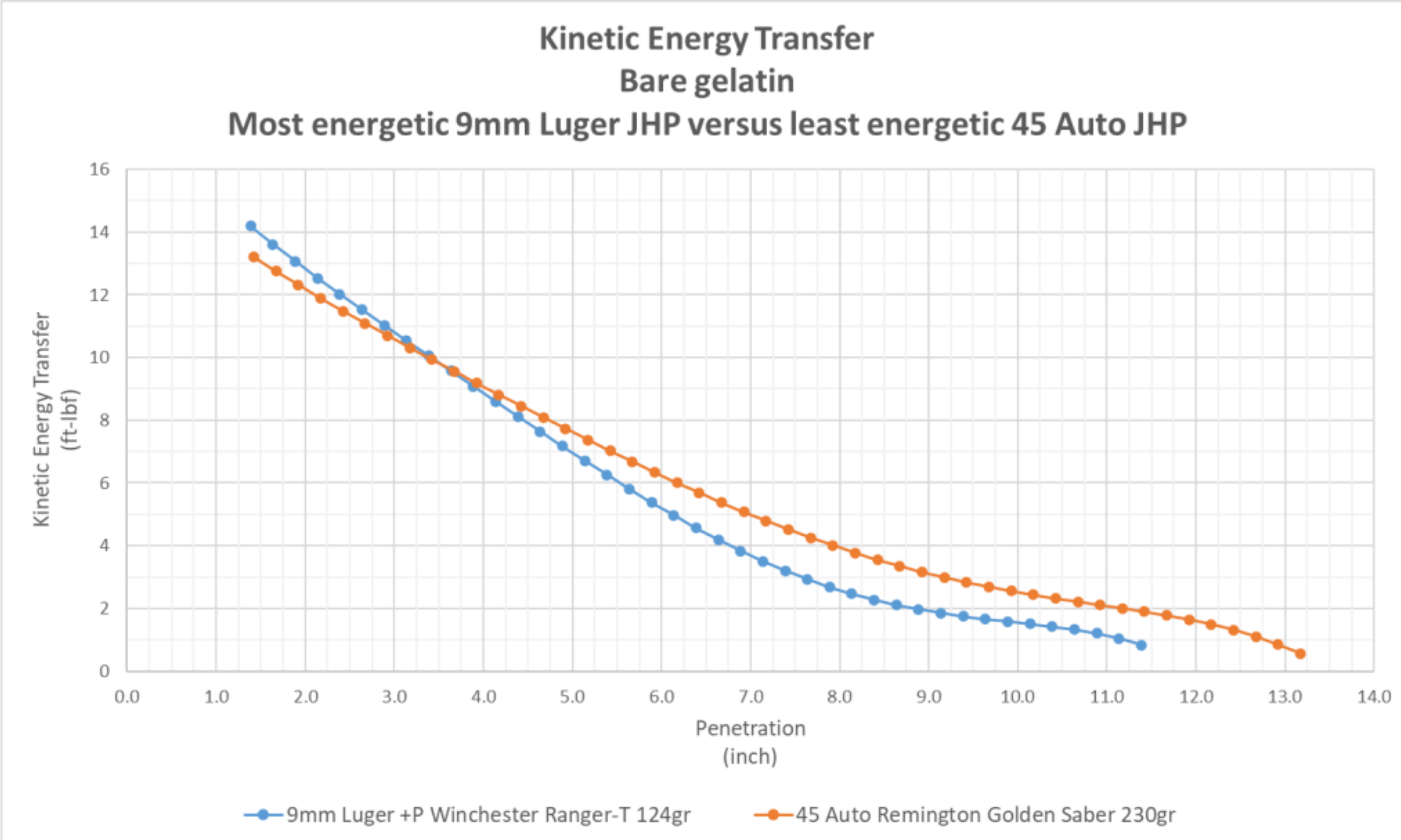
A bullet slows down as it penetrates. The slower the bullet, the more likely the gelatin is to stretch as opposed to break. Since a standard ballistic gelatin block is at least 16” deep, there is much supporting material in front of the bullet as it penetrates. Shooting thin sheets of gelatin as in the above verification method removes this supporting material and encourages stretching. This stretching has the tendency to produce numbers that are skewed slower than the bullet is in fact traveling in a standard-sized ballistic gelatin block.

The tested bullets are from the major ammunition manufacturers and are the same weight – the 9mm Luger bullets are 124gr and 45 Auto bullets are 230gr. Weight was kept constant so that results can be combined and represented accurately as an average.



The work done by the bullet to the gelatin is equal to the work done by the gelatin to the bullet and this is what we are calculating. 45 Auto kinetic energy transfer and thus terminal performance in bare gelatin is superior to 9mm Luger.

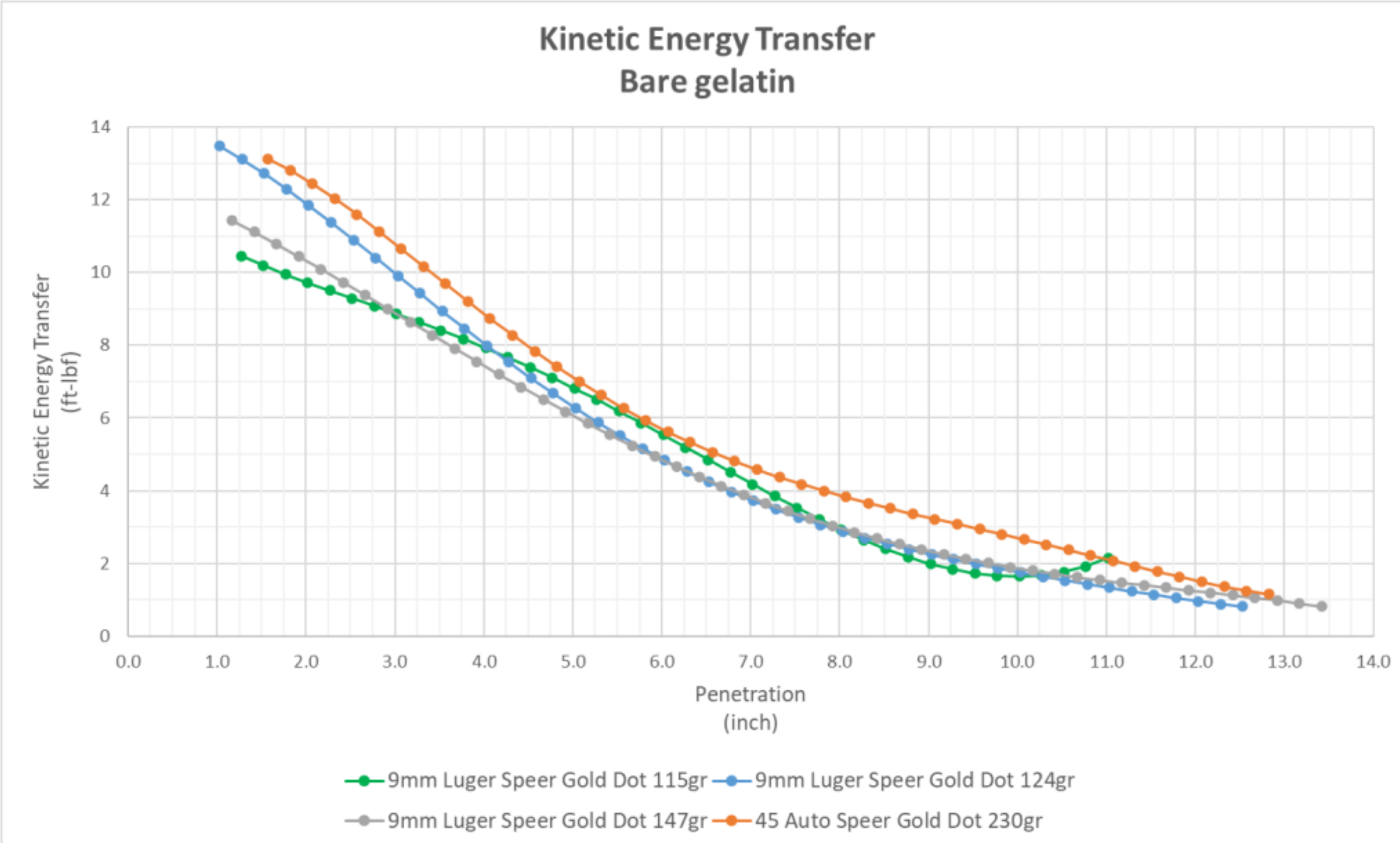
That was the average, the extremes follow. Below is a comparison of the 9mm Luger cartridge with the greatest kinetic energy at impact compared to the 45 Auto with the least kinetic energy at impact.



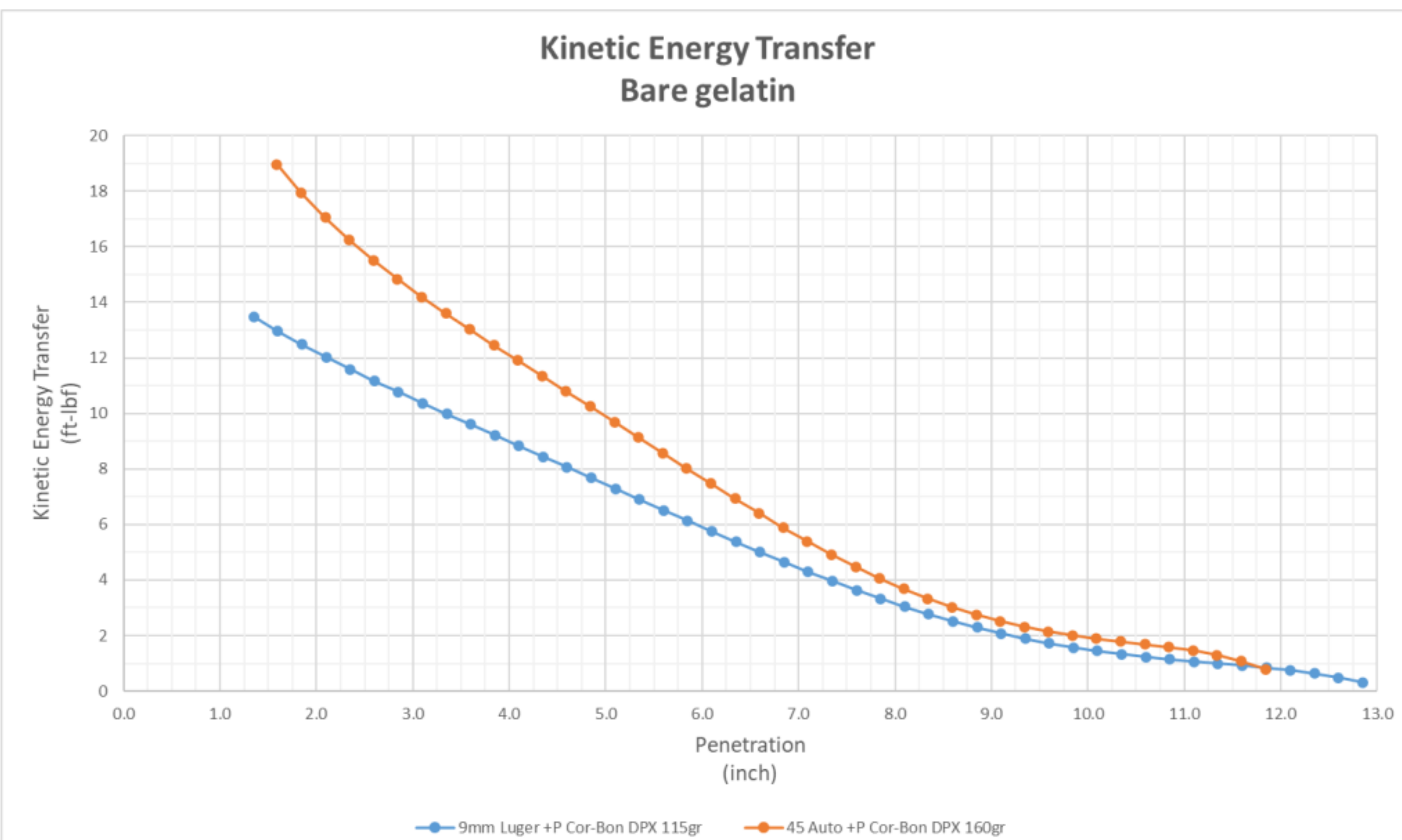
The 9mm Luger +P tested at 1180 $^{ft}/_{sec}$ is slightly more effective until 3.7″ penetration depth, after which the 45 Auto is superior, even when loaded light, to 810 $^{ft}/_{sec}$ as this ammunition was.

You've probably heard that the 9mm Luger is so much faster than 45 Auto and that velocity makes a difference. Other people argue that the 45 Auto does more damage because it is slower.

Cartridge	Velocity ($^{ft}/_{sec}$)	Penetration (inch)	Expansion (inch)	Retained weight (grain)	Kinetic Energy (ft-lbf)
9mm Luger Speer Gold Dot 115gr	1200	10.8	0.64	115	367
9mm Luger Speer Gold Dot 124gr	1120	12.5	0.58	124	345
9mm Luger Speer Gold Dot 147gr	950	13.1	0.55	147	292
45 Auto Speer Gold Dot 230gr	820	11.7	0.68	230	340
9mm Luger +P Cor-Bon DPX 115gr	1200	13.5	0.53	115	368
45 Auto +P Cor-Bon DPX 160gr	1200	12.2	0.61	159	520



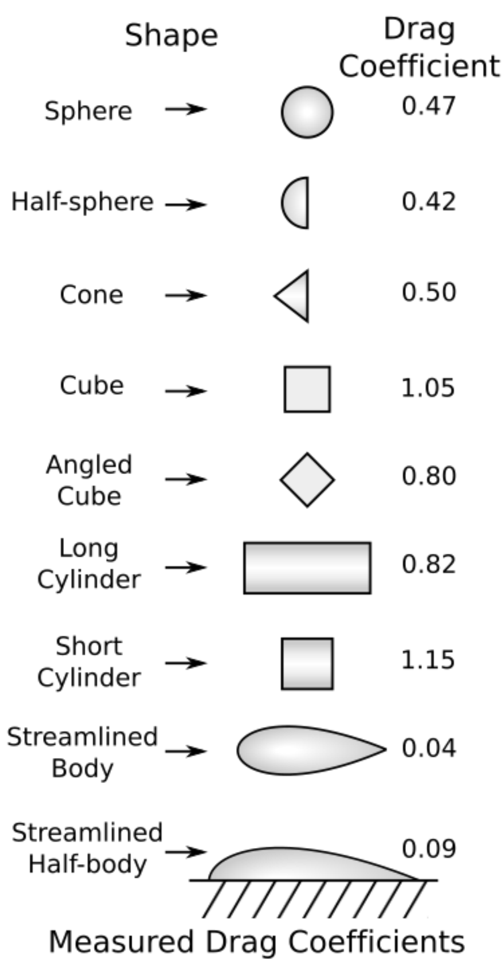
Using Speer Gold Dot as an example, a 45 Auto in the slower end of the velocity range still outperforms all weights of 9mm Luger in terms of kinetic energy transfer.



The Cor-Bon 9mm Luger +P DPX 115gr is one of the most energetic 9mm Luger cartridges available. The bullet traveled at 1200 $^{ft}/_{sec}$, 45 Auto +P DPX 160gr bullet also traveled at 1200 $^{ft}/_{sec}$ and is a 160gr bullet versus the 115gr bullet of the 9mm Luger. 45 Auto dominates here as well.

Drag Coefficient

An object moving through a fluid encounters resistance pushing the medium aside. Drag Coefficient is a unitless number that indicates resistance to flow – the higher the number, the more resistance the object will encounter moving through a fluid. The soft tissues of a living organism are filled with fluid so drag coefficient is relevant to bullets penetrating soft tissue. The larger the drag coefficient, the greater the damage to the tissue.



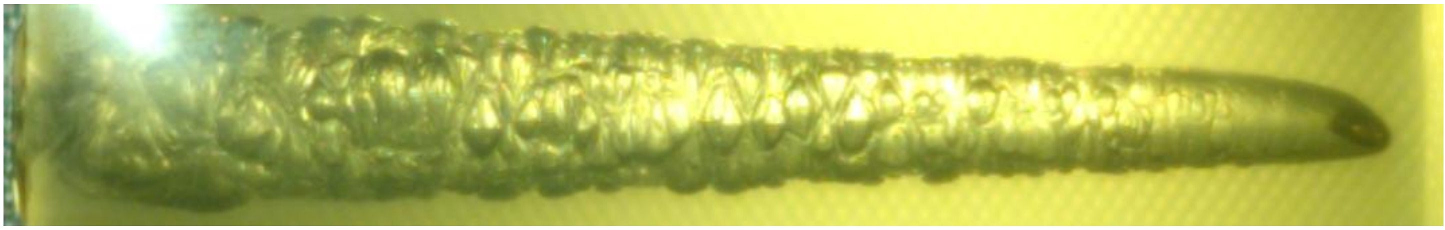
The graphic above illustrates influence of bullet shape on drag. These numbers should be considered relative – the drag coefficient varies with velocity and the properties of the fluid the object is moving through.

Here are some real numbers from high speed video of projectiles in ballistic gelatin:

Projectile	**Drag coefficient**
9mm Luger FMJ 115gr (tumbles early, 1190 fps – 690 fps)	0.03 – 0.88
45 Auto FMJ 230gr (tumbles late, 840 fps – 670 fps)	0.16 – 0.25
9mm Luger JHP 124gr (expanded, 1130 fps – 110 fps)	0.36 – 2.56
45 Auto JHP 230gr (expanded, 870 fps – 120 fps)	0.47 – 1.58

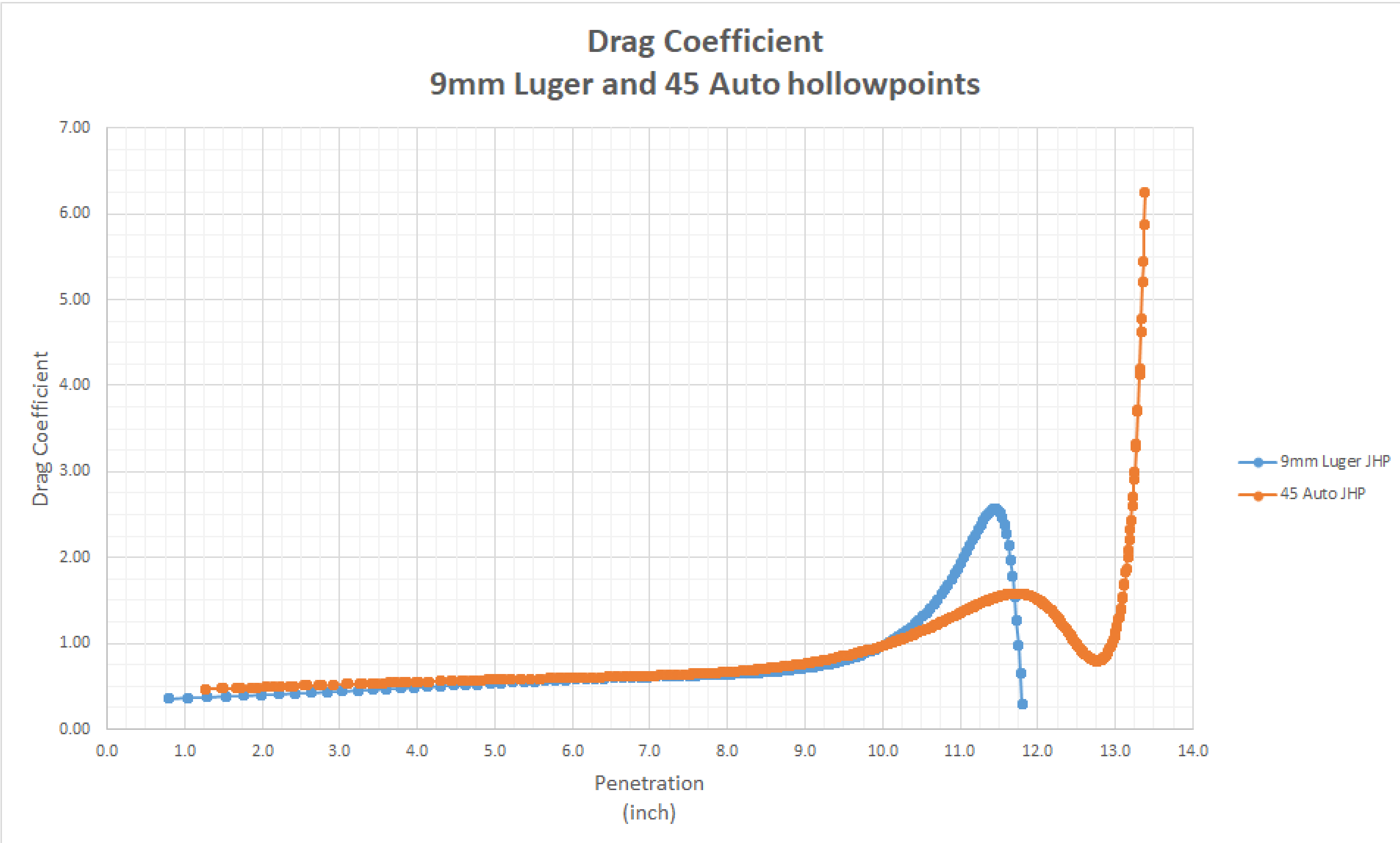
9mm Luger FMJ bullets feature a significantly larger ogive radius and a slightly greater length-to-diameter ratio than 45 Auto FMJ bullets so they are less stable passing through a target. This leads to tumbling early on in the penetration and greater wounding since a larger surface area is exposed to the fluid (increasing drag coefficient.)

9mm Luger FMJ 115gr tumbling



45 Auto FMJ 230gr tumbling

The below plot is the drag coefficients of all 9mm Luger and 45 Auto JHPs tested for this report.



The higher the drag coefficient, the less streamlined a body is and the more likely it is to damage tissue as it passes by. Drag coefficient is given by:

$$Cd = \frac{D}{\rho V^2 A / 2}$$

Where:

D = Drag force acting on bullet
ρ = Density of the fluid medium
V = velocity of the bullet
A = projected frontal surface area of the bullet

The drag coefficient of a 45 Auto JHP bullet is greater at all penetration distances until the turbulent-to-laminar flow transition (occurring at 9.0 inch penetration for 9mm Luger and 8.6 inch penetration for 45 Auto.) A higher drag coefficient indicates a less streamlined body and greater difficulty for fluid flow around the bullet. Gelatin which does not stretch around a passing bullet is physically damaged. 9mm Luger bullets at 9.0 inches penetration travel at 280 $^{ft}/_{sec}$ and 45 Auto bullets at 8.6 inches penetration travel at 283 $^{ft}/_{sec}$ on average. With this knowledge, what becomes important is the discussion of the differences between bullets with regard to expanded bullet diameter and sectional density. The Reynolds number is a dimensionless quantity in fluid dynamics, one use of which is to determine whether an object at a given velocity is experiencing turbulent, laminar or creeping flow. It is given by:

$$\mathrm{Re} = \frac{\rho u L}{\mu} = \frac{u L}{\nu}$$

Where:

u is the velocity of the bullet
L is the diameter of the bullet
v is the kinematic viscosity of the fluid

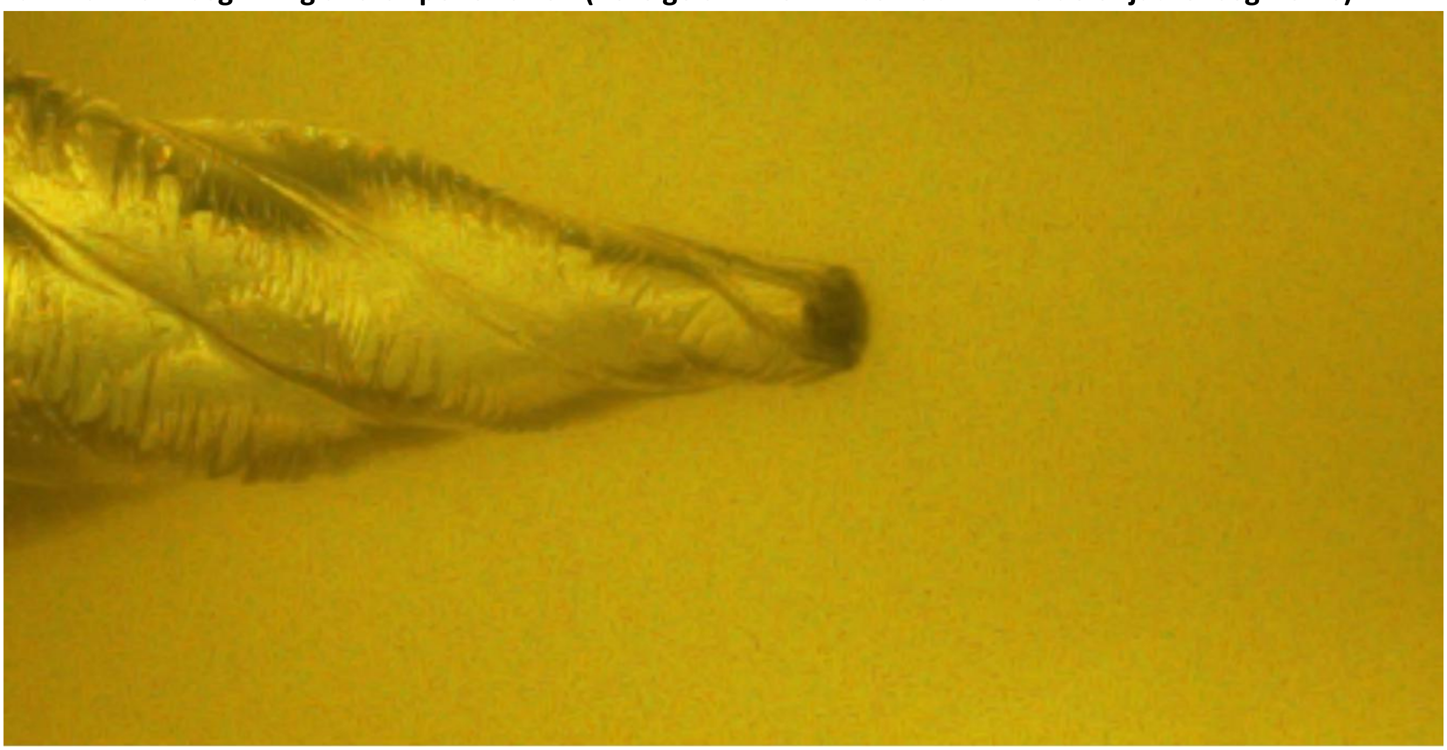
Since all shots were into the same ballistic gelatin medium, we can disregard kinematic viscosity because it is a property of the gelatin and was constant. The Reynolds number at the laminar transition is then equal to the product of the velocity and diameter of the expanded bullets. Since the velocity of the 9mm Luger bullets at the laminar transition was 280 $^{ft}/_{sec}$ and the 45 Auto bullets velocity at the laminar transition was 283 $^{ft}/_{sec}$, we can call the velocities equal. This functionally makes the diameter of the bullets equal in the equation so we can consider the wetted diameter of the 9mm Luger bullets to be equal to the 45 Auto in the turbulent (IE high velocity) flow regime.

For visual reference, 9mm Luger Remington Golden Saber 124gr is shown below at the significant events of penetration.

Expansion at 0.66" penetration

Turbulent flow at 7.5” penetration

Laminar flow beginning at 9.6” penetration (note gelatin now in contact with side of jacket segments)

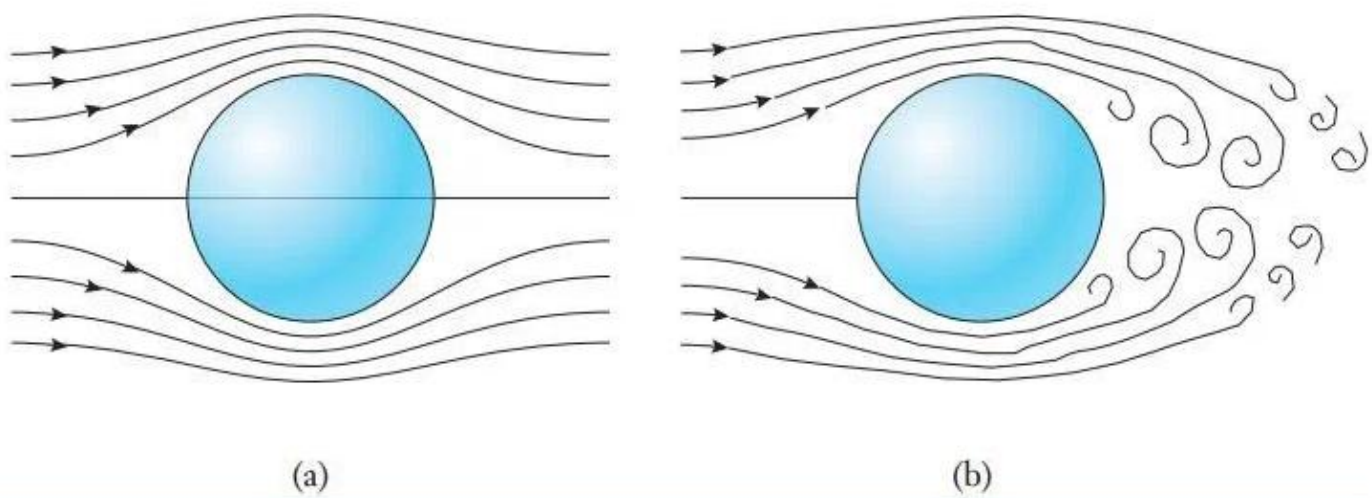


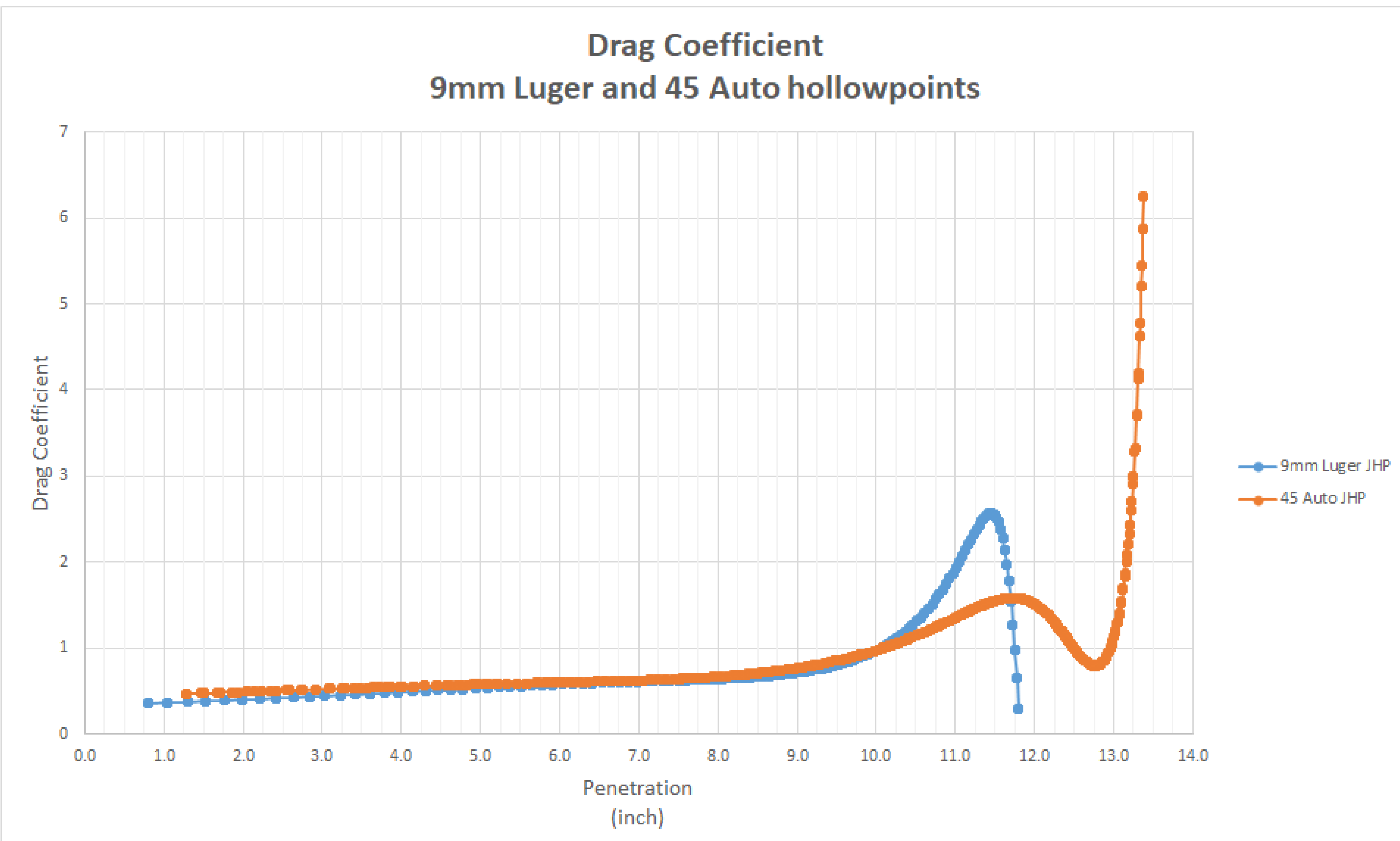
Creeping flow for last 0.85” penetration

End of bullet penetration at 12.2”

We have seen that the 9mm Luger and 45 Auto JHPs are functionally equivalent during the turbulent flow phase of penetration. Regarding the other flow regimes – at the transition point from turbulent to laminar, the 9mm Luger JHPs were moving at 280 ft/sec for a kinetic energy of 21 ft-lbf and the 45 Auto JHPs were moving at 283 ft/sec for a kinetic energy of 41 ft-lbf. This is of small significance and is the same amount of kinetic energy that a 41 pound object has when dropped a distance of one foot and is 11% of the original kinetic energy at bullet impact with the gelatin.

Laminar flow (a) is characterized by a lack of a turbulent wake (b) behind the penetrating object:





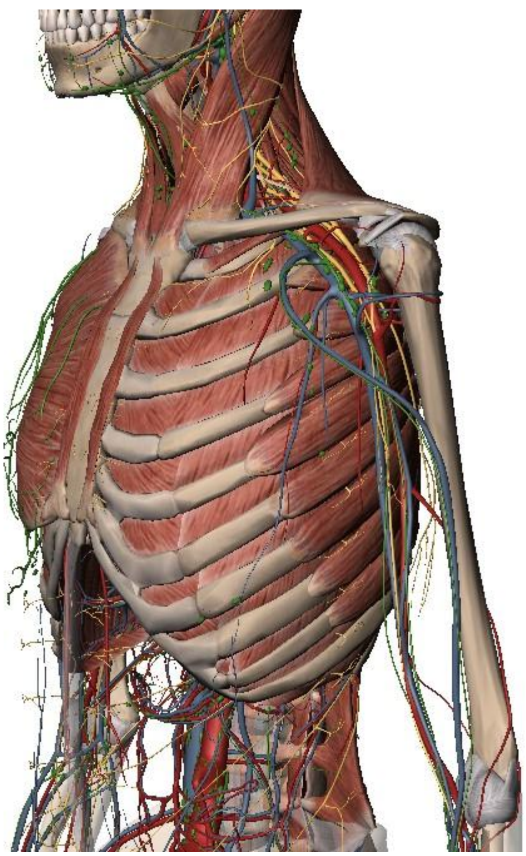
From 10.0" to 11.4" the 9mm Luger JHPs have a significantly higher drag coefficient than 45 Auto. This is due to the smaller length to diameter ratio of the expanded 9mm Luger creating greater pressure drag due to the larger void at the rear of the bullet. The wetted diameters of the 9mm Luger and 45 Auto JHPs were measured on an optical comparator and the length was measured from the face of the JHP to the base of the bullets.

Length to diameter ratio	9mm Luger	45 Auto
	0.78	0.86

A 9mm Luger JHP has the advantage in wounding capability during laminar flow from 10.0” to 11.4” but this only accounts for 10% of a JHPs overall penetration depth and is likely deeper than the vital organs would be found on most shotlines.

By the time creeping flow occurs, a 9mm Luger JHP will be moving at 120 $^{ft}/_{sec}$ with a kinetic energy of 4 ft-lbf and a 45 Auto JHP will be moving at 125 $^{ft}/_{sec}$ with a kinetic energy of 8 ft-lbf. Creeping flow is characterized by the dominance of fluid viscosity and a collapse of the void formed by the passage of a bullet. The 45 Auto has the advantage in wounding in this flow regime due to its greater kinetic energy and diameter and the theoretical advantage the larger diameter bullet has in being able to cut an organ that would have overwise been missed or pushed out of the way.

PERFORMANCE AGAINST BONE



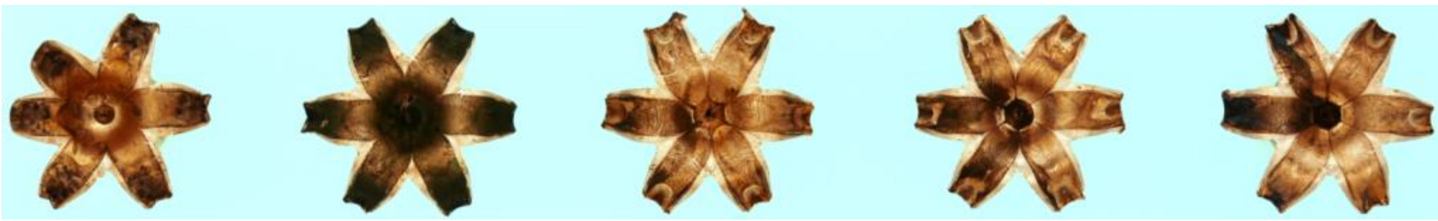
Bullets frequently hit bone during gunfights. The vast majority of JHP bullets must hit soft tissue prior to bone or they will not expand. Quoting the FBI's *Handgun Wounding Factors and Effectiveness*:

"Handgun bullets expand in the human target only 60-70% of the time at best. Damage to the hollow point by hitting bone, glass, or other intervening obstacles can prevent expansion."

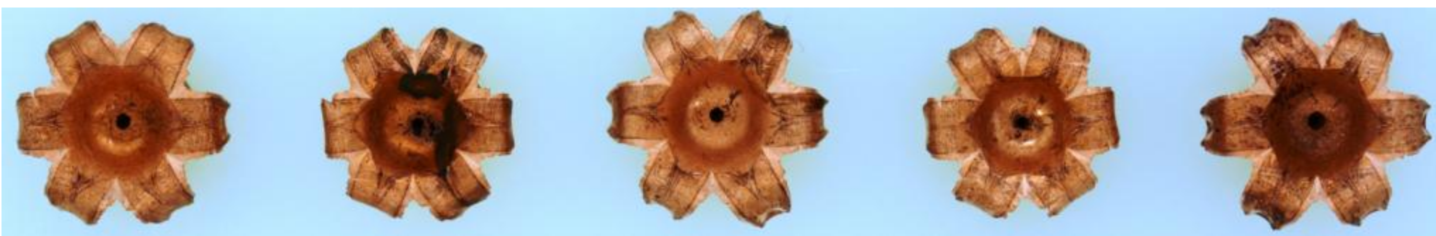
It is reasonable to expect conventional pistol JHPs to fail to expand most of the time. What matters is how to make this bad situation better in the likely event it occurs. 70 rounds of premium 9mm Luger expanding ammunition and 60 rounds of premium 45 Auto expanding ammunition were shot through bare gelatin blocks and through Synbone 6mm thick bone simulant plate placed in front of bare gelatin blocks.

Synbone 6mm thick bone simulant plate in front of bare gelatin block

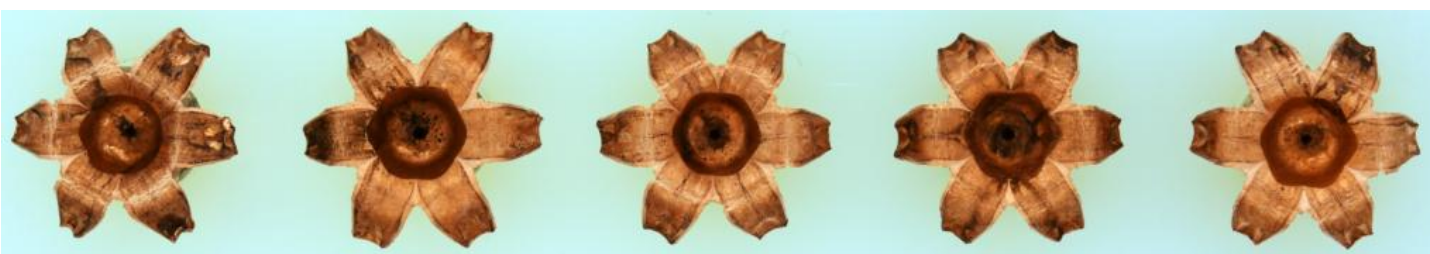
9mm Luger +P Cor-Bon DPX 115gr through bare gelatin



9mm Luger +P Cor-Bon DPX 115gr through bone plate



45 Auto +P Cor-Bon DPX 160gr through bare gelatin



45 Auto +P Cor-Bon DPX 160gr through bone plate

9mm Luger Federal EFMJ 105gr through bare gelatin

9mm Luger Federal EFMJ 105gr through bone plate

45 Auto Federal Guard Dog EFMJ 165gr through bare gelatin

45 Auto Federal Guard Dog EFMJ 165gr through bone plate

9mm Luger +P+ Federal Tactical Hydra-Shok 124gr through bare gelatin

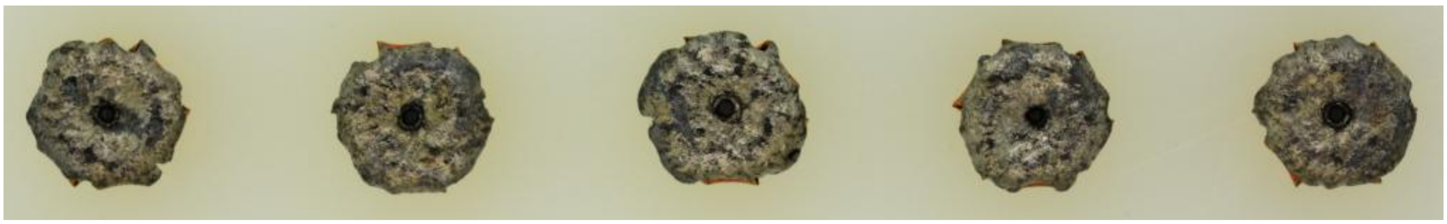
9mm Luger +P+ Federal Tactical Hydra-Shok 124gr through bone plate

45 Auto Federal Personal Defense Hydra-Shok 230gr through bare gelatin

45 Auto Federal Personal Defense Hydra-Shok 230gr through bone plate

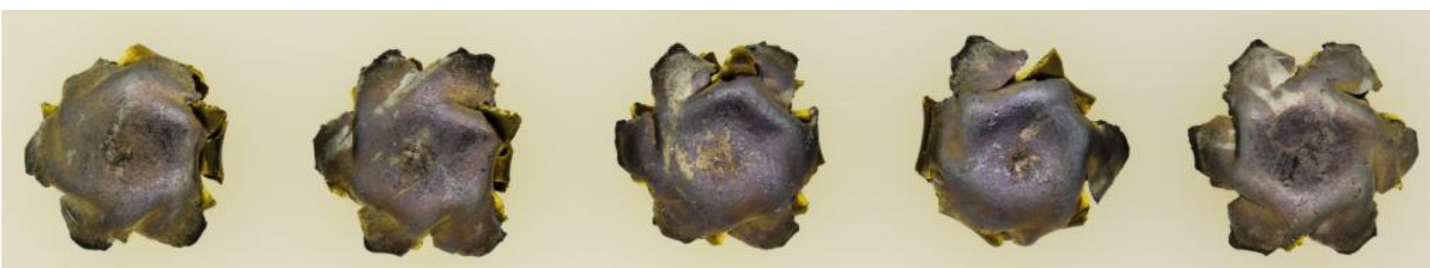
9mm Luger Hornady Critical Defense 115gr through bare gelatin

9mm Luger Hornady Critical Defense 115gr through bone plate

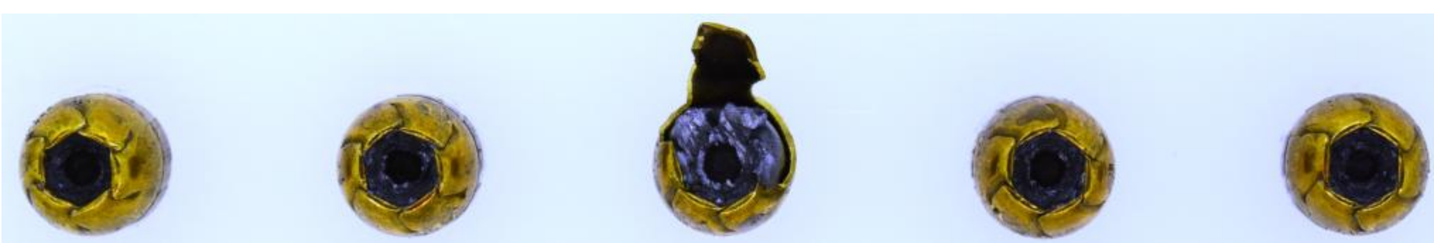


9mm Luger Hornady XTP 124gr through bare gelatin

9mm Luger Hornady XTP 124gr through bone plate



45 Auto +P Golden Saber 185gr through bare gelatin



45 Auto +P Golden Saber 185gr through bone plate

9mm Luger Speer Gold Dot 115gr through bare gelatin

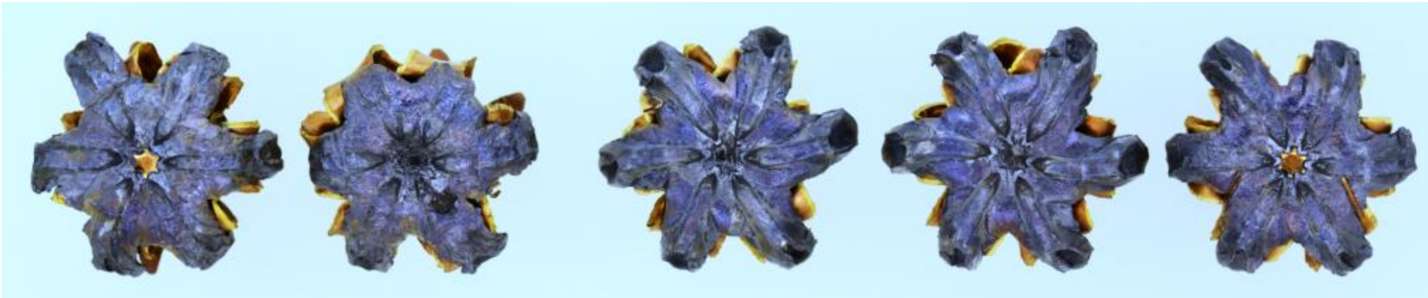
9mm Luger Speer Gold Dot 115gr through bone plate

9mm Luger Speer Gold Dot G2 147gr through bare gelatin

9mm Luger Speer Gold Dot G2 147gr through bone plate

45 Auto +P Speer Gold Dot 200gr through bare gelatin

45 Auto +P Speer Gold Dot 200gr through bone plate



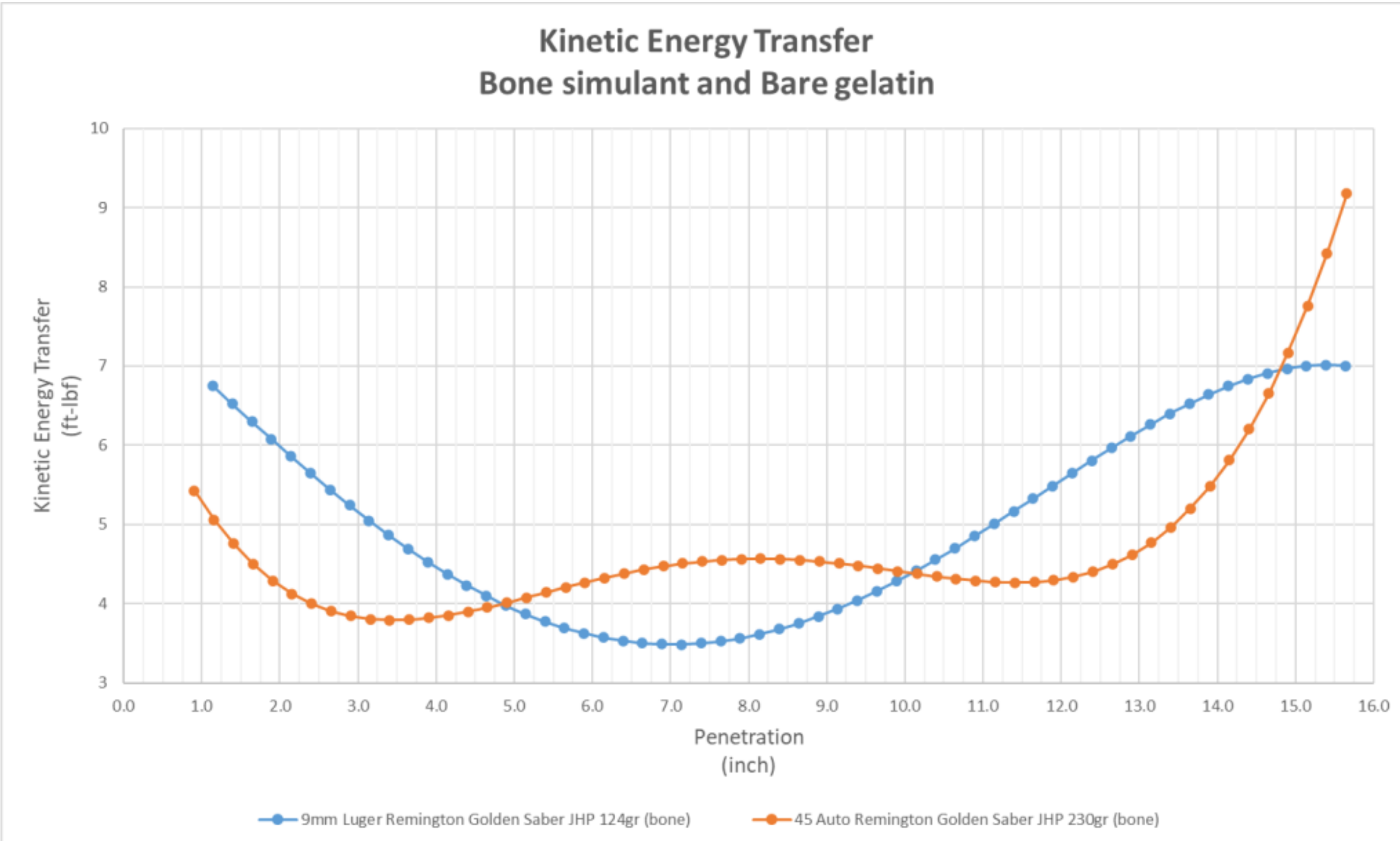
45 Auto +P Winchester Ranger-T 230gr through bare gelatin

45 Auto +P Winchester Ranger-T 230gr through bone plate

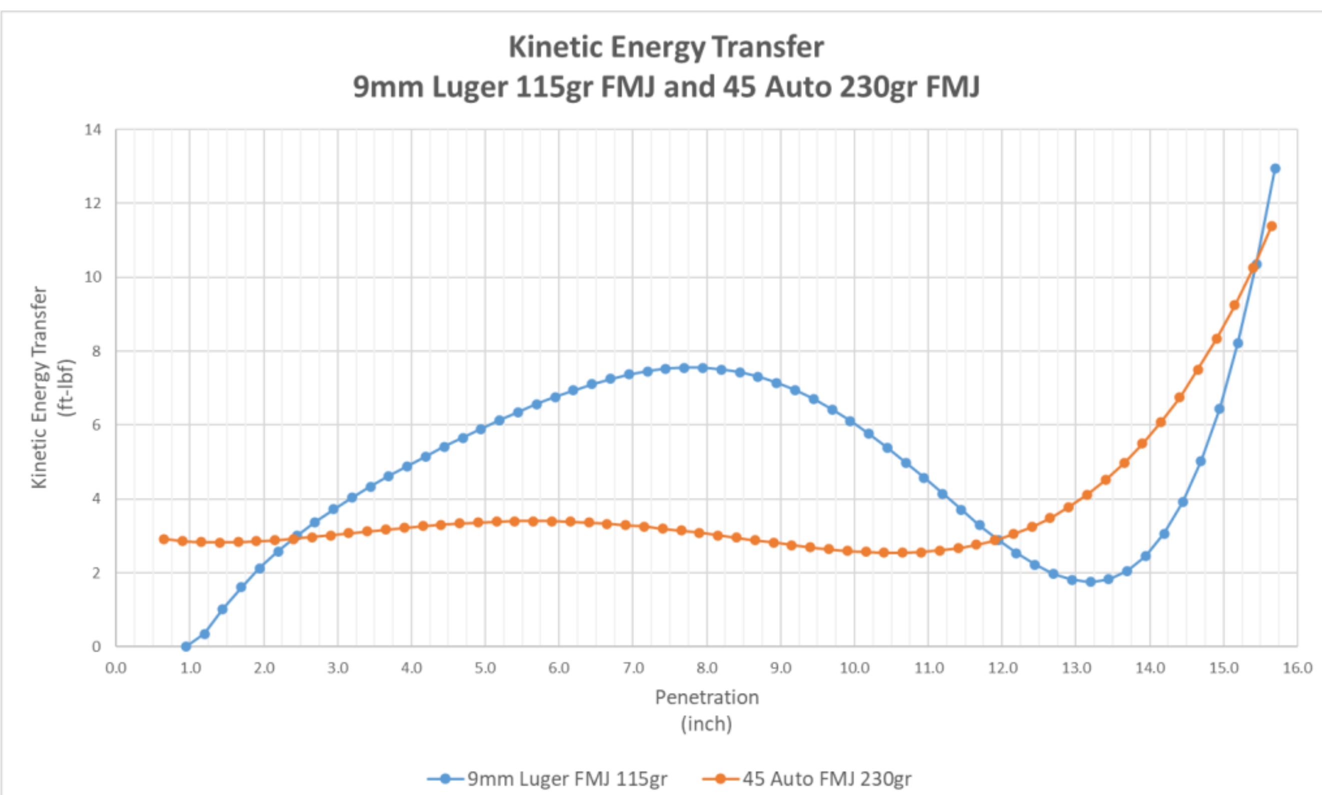
The table below shows the performance of these bullets in bare gelatin and bone simulant plus gelatin in {brackets} immediately to the right. For example, a 9mm Luger +P Cor-Bon DPX 115gr bullet penetrates 13.5″ in bare gelatin and 12.0″ in bare gelatin placed behind the bone plate. The metric of Average Kinetic Energy Transfer is the bullets kinetic energy at impact with the gelatin, divided by the penetration depth. The table below shows the average of five shots per cartridge.

Cartridge	Average KE Transfer (ft-lbf/inch)	Velocity (ft/sec)	Penetration (inch)	Expansion (inch)	Retained Weight (grain)
9mm Luger +P Cor-Bon DPX 115gr	28 {30}	1210 {1220}	13.5 {12.0}	0.53 {0.54}	115 {115}
45 Auto +P Cor-Bon DPX 160gr	42 {43}	1210 {1200}	12.2 {11.2}	0.61 {0.63}	159 {159}
9mm Luger Federal EFMJ 105gr	39 {30}	1200 {1200}	8.7 {10.4}	0.61 {0.52}	105 {104}
45 Auto Federal Guard Dog EFMJ 165gr	51 {44}	1050 {1050}	7.9 {8.6}	0.74 {0.68}	164 {164}
9mm Luger +P+ Federal Hydra-Shok 124gr	31 {17}	1160 {1160}	9.4 {20.9}	0.62 {0.36}	97 {123}
45 Auto Federal Hydra-Shok 230gr	29 {17}	900 {900}	12.9 {23.2}	0.61 {0.45}	207 {231}
9mm Luger Hornady Critical Defense 115gr	33 {16}	1170 {1170}	10.2 {20.1}	0.55 {0.36}	110 {115}
9mm Luger Hornady XTP 124gr	25 {15}	1110 {1110}	12.8 {20.8}	0.50 {0.36}	116 {124}
45 Auto +P Remington Golden Saber 185gr	41 {18}	1060 {1060}	10.8 {23.3}	0.68 {0.47}	179 {183}
9mm Luger Speer Gold Dot 115gr	35 {15}	1230 {1250}	10.9 {25.7}	0.61 {0.36}	114 {116}
9mm Luger Speer Gold Dot G2 147gr	23 {14}	990 {990}	14.0 {21.5}	0.58 {0.36}	146 {147}
45 Auto +P Speer Gold Dot 200gr	54 {17}	1060 {1070}	9.2 {27.8}	0.84 {0.45}	199 {201}
45 Auto +P Winchester Ranger-T 230gr	40 {18}	930 {920}	10.8 {22.2}	0.72 {0.45}	224 {230}
9mm Luger Average	**30 {20}**	**1150 {1160}**	**11.4 {18.8}**	**0.57 {0.41}**	**115 {121}**
45 Auto Average	**43 {26}**	**1040 {1030}**	**10.6 {19.4}**	**0.70 {0.52}**	**189 {195}**

The DPX copper bullets and Federal EFMJ bullets expanded after hitting bone. No jacketed lead core bullets expanded. Below is what to expect in terms of kinetic energy transfer from bullets which do not expand.

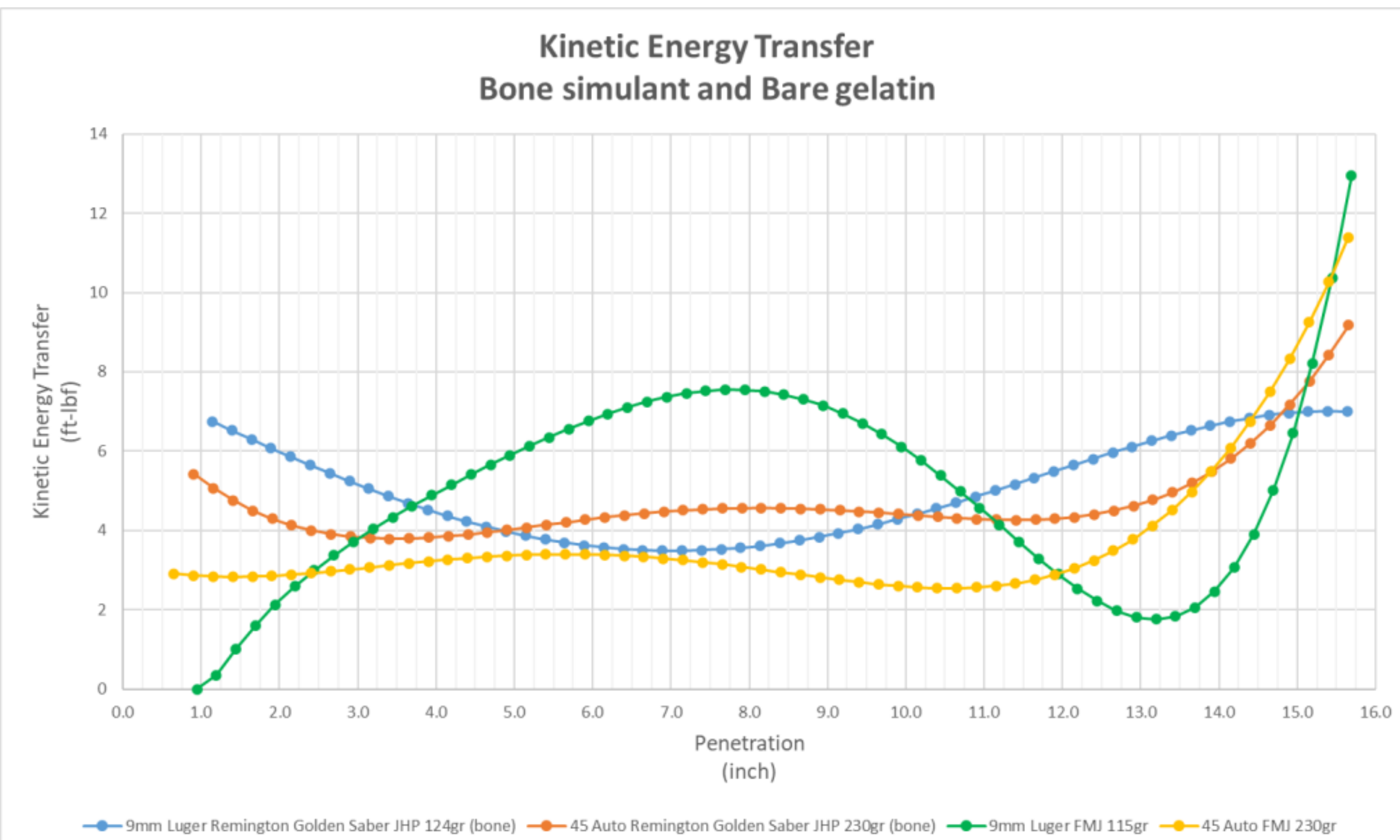


9mm Luger and 45 Auto Remington Golden Saber, performed equally as bad after failing to expand after bone. There is a saying that goes: "they all fall to hardball." Hardball being slang for a 45 Auto FMJ 230gr bullet.



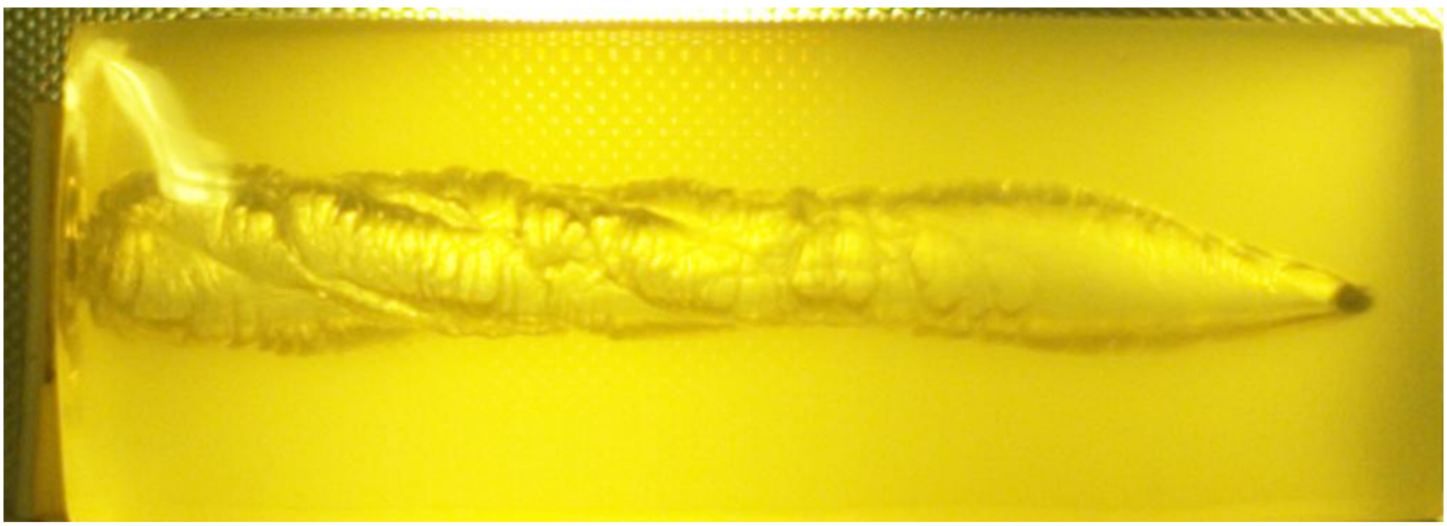
Whoever said that about 45 Auto FMJ 230gr must not have been aware that the 9mm Luger FMJ, which has significantly better terminal performance in bare gelatin than 45 Auto, is also a huge underperformer in real life. An example of this is the Amadou Diallo shooting in 1999. Diallo was shot at 41 times by the NYPD and hit 19 times (accounts vary) with 9mm FMJ before he collapsed. That is a hit probability of 46% against a subject who was unarmed. Nervousness increases greatly if the subject is fighting back so expect to get even worse than 46% hits in a gunfight.

9mm Luger FMJ is more effective in soft tissue than 45 Auto FMJ because the ratio of length to diameter is greater with the 9mm FMJ – it is more like a rifle bullet shape than 45 Auto FMJ 230gr. If you live in a political jurisdiction that doesn't respect your right to self-defense and restricts gun owners to FMJ only, you should move for this and many other reasons. If that is not possible then use 9mm FMJ 147gr to maximize the length-to-diameter ratio which leads to bullet instability and earlier tumbling in soft tissue. This is how a JHP that fails to expand after bone compares to both 9mm FMJ 115gr and 45 Auto FMJ 230gr:



We are not recommending 9mm FMJ over JHPs in either caliber for any reason. There are still many shotlines through vital areas that hit soft tissue first, so expanding bullets still provide great advantage. The above graph provides a reference to understand how poorly both pistol FMJs and JHPs that fail to expand in soft tissue perform. Below are still images taken from high speed video of this testing.

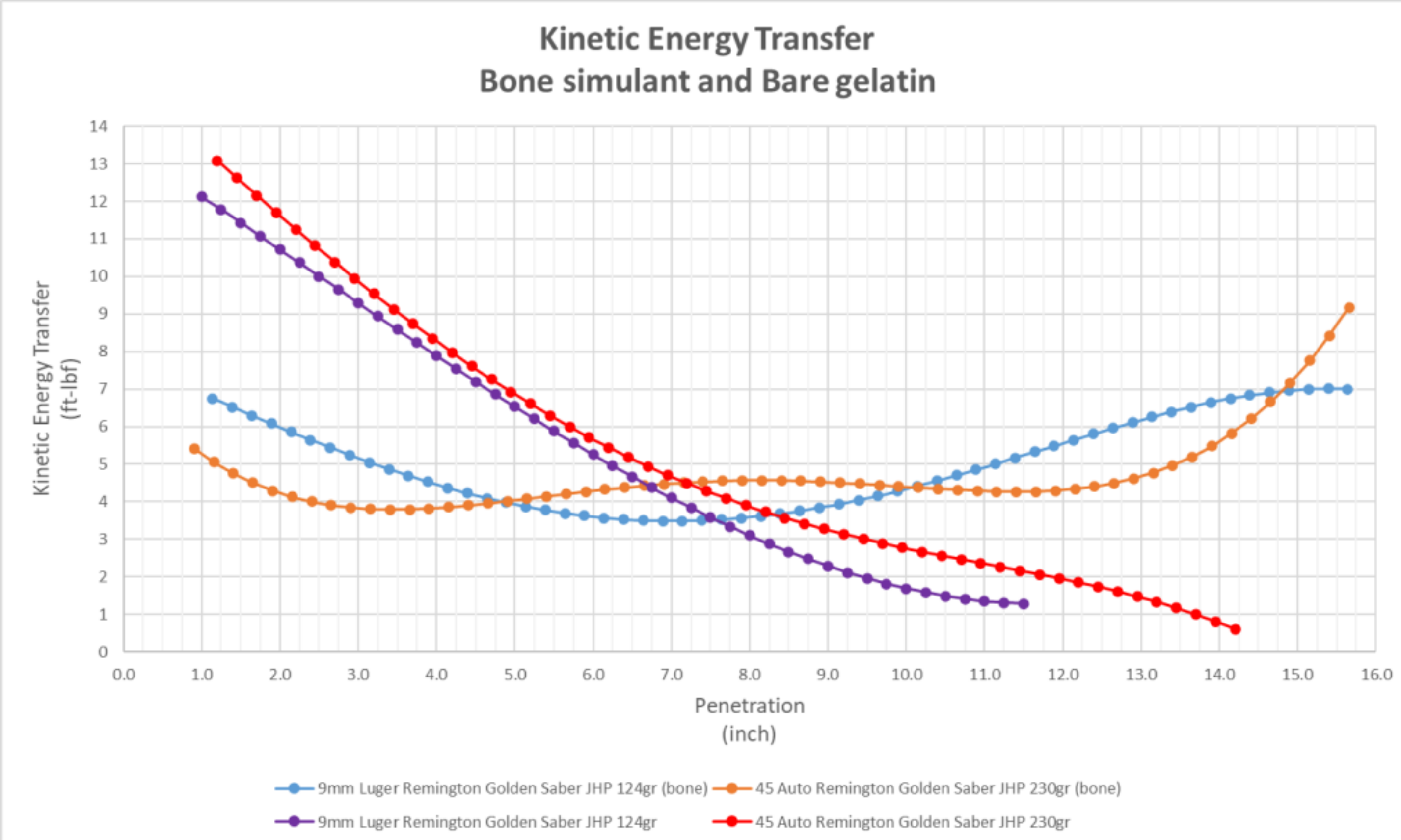
9mm Luger Remington Golden Saber 124gr in bare gelatin



9mm Luger Remington Golden Saber 124gr failure to expand after striking bone

45 Auto Remington Golden Saber 230gr in bare gelatin

45 Auto Remington Golden Saber 230gr failure to expand after striking bone



JHPs that fail to expand are more effective after 7 inches of soft tissue. The vital organs are located well within 7 inches of the skin on the vast majority of shotlines so it goes without saying how important JHP expansion is to wounding efficiency.

The only bullets that performed well against bone were the Cor-Bon DPX (Barnes TAC-XP) and Federal Expanding Full Metal Jacket. Cor-Bon doesn't currently load the DPX 160gr to +P pressure and Federal currently doesn't catalog Expanding Full Metal Jacket. These bullets function when conventional jacketed lead hollowpoints don't because they do not plug with bone as easily or at all in the case of the EFMJ.

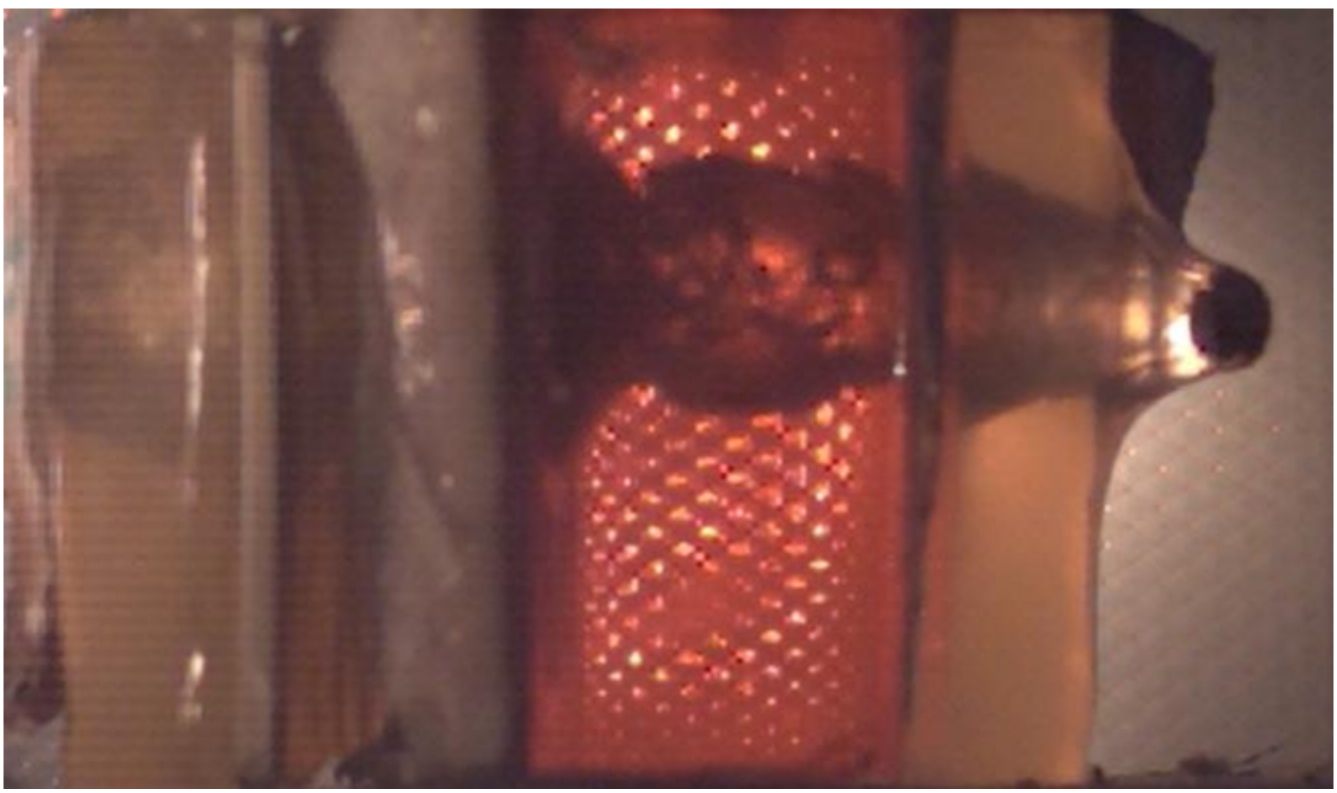
Federal EFMJ (Guard Dog) is a jacketed lead core bullet with polymer ball in the ogive/meplat area.

Image from https://www.firearmsid.com/bullets/bullet1.htm

The EFMJ cannot plug and fail to expand because it doesn't have a cavity to plug. Barnes copper pistol bullet cavities can accommodate foreign material such as bone while still allowing fluid around the plug to fill the cavity and cause expansion.

9mm Luger +P Cor-Bon DPX 115gr impacted the bone at the same velocity as 45 Auto. The expansion of both wasn't affected by bone. 45 Auto DPX averaged 43 ft-lbf kinetic energy transfer per inch of penetration and 9mm Luger DPX averaged 30 ft-lbf kinetic energy transfer per inch of penetration. 45 Auto EFMJ also performed comparatively better than the 9mm Luger EFMJ. All conventional JHPs tested failed to expand after impact with bone.

Once someone feels like a deeply held opinion is challenged by laboratory data, they will quickly denounce the testing as not being representative of the 'real world'. The following tests use simulant materials (pig skin, bone plate, gelatin) with the same density and arrangement as real-world targets (shots to rib cage, femur and pelvis.)



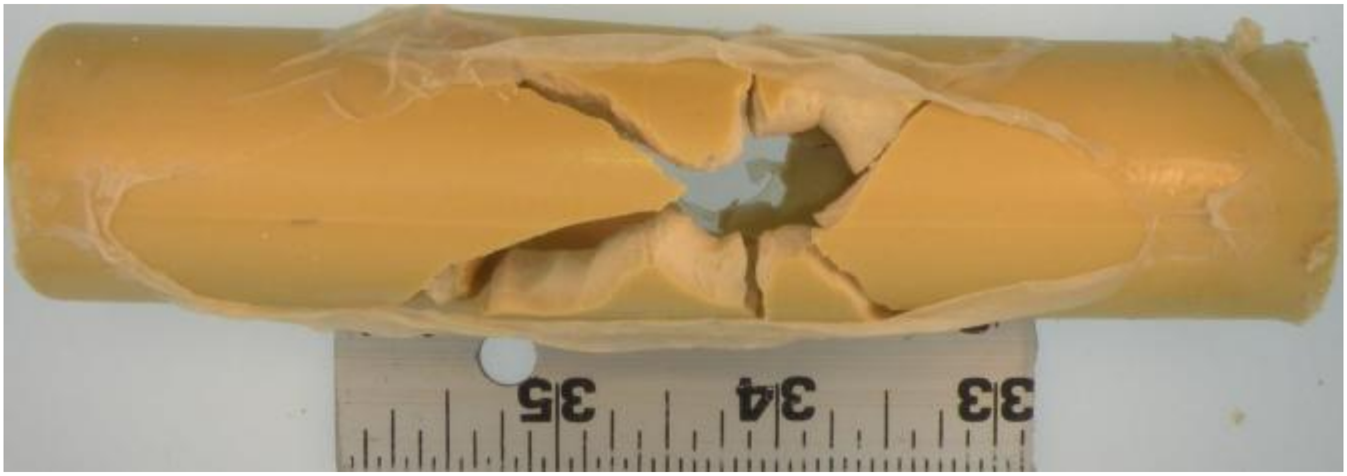
Rib cage (pig skin, 10% gelatin, bone plate, 10% gelatin, 10% gelatin foam, 25% gelatin, 10% gelatin)

Three shots of Speer 9mm Luger +P Gold Dot 124gr were shot into this target and lost 357 ft-lbf kinetic energy. Three shots of Hornady 45 Auto +P XTP 230gr were shot into this target and lost 367 ft-lbf kinetic energy.

Femur simulant target (pig skin, 10% gelatin, bone tube, 10% gelatin, pig skin)

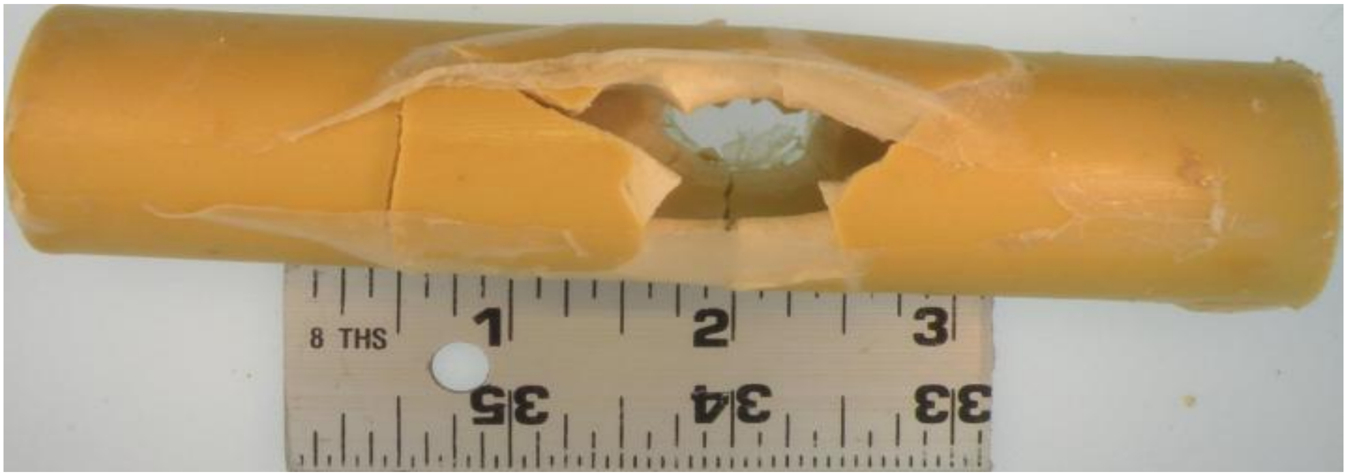
The 9mm Gold Dot lost 158 ft-lbf in this target while the 45 Auto XTP lost 205 ft-lbf in this target simulating the thigh.

Rear view of femur simulant target shot by 9mm JHP. Note complete fracturing of bone.



Bone tube shot by 9mm Luger JHP

Rear view of femur simulant target shot by 45 Auto JHP. Note complete fracturing of bone.



Bone tube shot by 45 Auto JHP

Both bullets damaged the bone tubes enough that they could not bear any weight. An adversary receiving a wound like this would be challenged to maneuver around cover or rush your position.


Pelvis (pig skin, 10% gelatin, bone plate)

A hit that damages the pelvis will greatly limit mobility. Shots to the pelvis and femur might be the only realistic aim points if an adversary is protected by body armor.

In the pelvis target, 45 Auto transferred 201 ft-lbf and 9mm Luger transferred 191 ft-lbf.

The greater terminal performance of 45 Auto versus 9mm Luger is again apparent with these simulations of real-world targets.

FBI BARRIER TEST PERFORMANCE

When the FBI buys ammo, it publishes a list of performance criteria that ammo must meet. These criteria are commonly referred to as the FBI Barrier Test Protocol. This test protocol consists of shooting bullets through bare gelatin, bare gelatin covered in heavy clothing and through barriers including drywall, plywood, sheet metal and automobile glass. Full details about the FBI protocol here. Unless your actions are covered by qualified immunity, you should think deeply about the rationale of making ammunition selections based on what a bullet will do on a blind shot through these barrier materials. Regardless of the circumstances that preceded the shot (example: adversary using a door frame for cover), pulling the trigger still violates the safety rule of knowing your target and what is beyond. A bullet must penetrate 12.0" or deeper in ballistic gelatin to do well in the FBI Barrier Test Protocol. Any bullet that does not meet this minimum depth will score poorly and not sell to many law enforcement agencies. Many law enforcement agencies will base their ammunition procurements on what the FBI finds did the best in their testing. An FBI ammunition contract is lucrative and this greatly influences the terminal performance of JHPs on the market.

The 'FBI Score' of a bullet is a number of points out of 500. Every solicitation from the FBI seems to have slightly different scoring criteria in the same cartridge and there are significant differences in criteria between two different cartridges. Here are some scores for both 9mm Luger and 45 Auto products:

Cartridge	FBI Score
9mm Luger +P Hornady American Gunner XTP 124gr	235
45 Auto +P Hornady XTP 230gr	265
9mm Luger Remington Golden Saber 124gr	200
45 Auto Remington Golden Saber 230gr	225
9mm Luger +P Winchester Ranger-T 124gr	75
45 Auto Winchester Ranger-T 230gr	73

9mm barrel was 4" long, 45 Auto barrel was 5" long (per SAAMI standard)

The cartridges above were not specifically marketed as being made for the law enforcement market so it is reasonable to expect mixed performance when shooting these through the FBI Barrier Tests. Speer makes the Gold Dot 2 specifically to do well in the FBI Barrier Tests.

Cartridge	FBI Score
9mm Luger Speer Gold Dot G2 147gr	315
45 Auto +P Speer Gold Dot G2 230gr	294

As mentioned earlier, the scoring criteria is a caliber-specific score out of 500 points possible. Note that an assailant doesn't care what caliber you are using. They only care if you have a gun or not and are willing to fight. Assuming a future justified use of force – the target will be the same, and you have the choice to decide now what ammo you will be carrying. Since we want to find out which cartridge is better for shooting through barriers, the 9mm Gold Dot G2 was scored using the 45 Auto criteria.

Cartridge	FBI Score
9mm Luger Speer Gold Dot G2 147gr	260
45 Auto +P Speer Gold Dot G2 230gr	294

Using FBI scoring criteria and two bullets designed to perform as well as possible on the FBI Protocol, 45 Auto scored higher than 9mm Luger.

Shooting blindly through barriers is already legally and tactically questionable. But let's go on and look at how much energy each bullet has to work with after passing through the opposite side of the FBI barrier materials.

Barrier Material	9mm Luger 124gr JHP	45 Auto 230gr JHP
Auto Glass	62%	64%
Steel	46%	56%
Plywood	14%	28%
Interior Wall	9%	14%

Percent kinetic energy lost penetrating FBI barrier materials

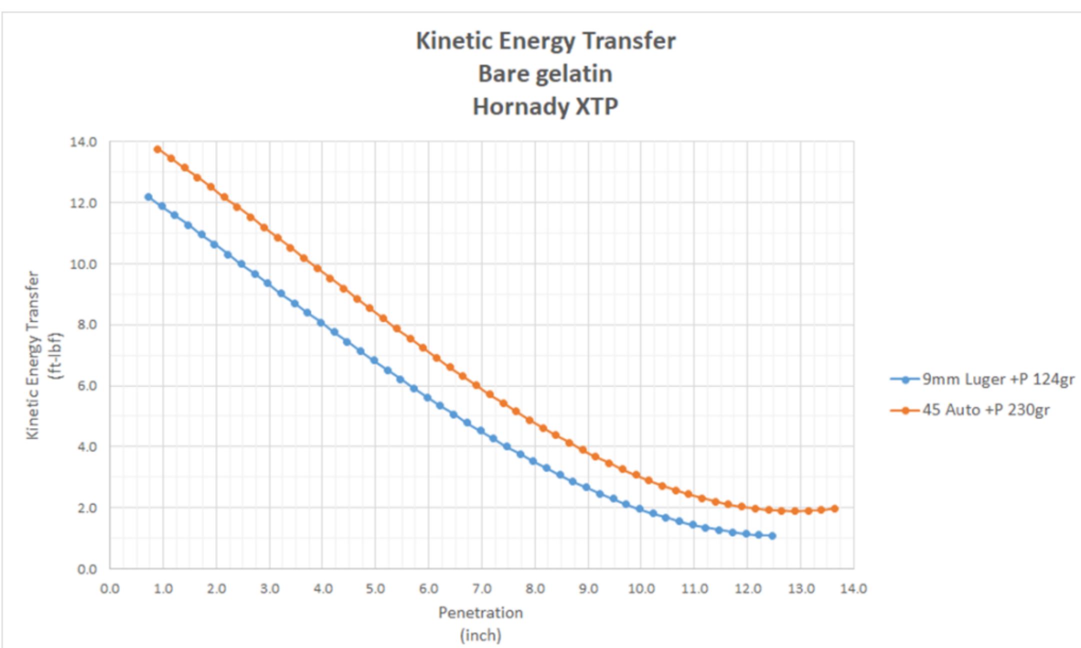
The biggest takeaway in the above table is the large amount of kinetic energy lost when a pistol bullet encounters a barrier and the similar performance in terms of barrier penetration 'efficiency' between 9mm and 45 Auto. In both cases you are starting off with not much gun (a handgun) and end up with much less once you start shooting through barriers.
Below is how many common 9mm Luger and 45 Auto bullets from full-size handgun length barrels function in the FBI Barrier Test Protocol.

Bare Gelatin

Bare gelatin (10% ballistic gelatin block)

Here is what bullets recovered from Bare gelatin look like:

Kinetic energy transfer of the Hornady 9mm Luger +P American Gunner XTP 124gr and Hornady 45 Auto +P XTP 230gr in bare gelatin:



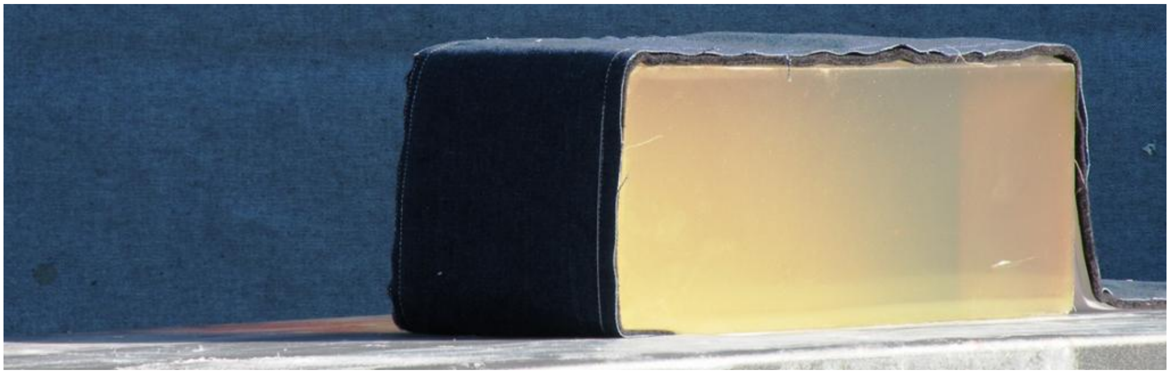
Advantage 45 Auto.

	Cartridge	Average kinetic energy transfer ($^{ft\text{-}lbf}/_{inch}$)
Bare gelatin	9mm Luger Barnes TAC-XPD 115gr	25
	9mm Luger +P Cor-Bon DPX 115gr	28
	9mm Luger Federal Hi-Shok 115gr	33
	9mm Luger Federal Hi-Shok 147gr	27
	9mm Luger Federal HST 124gr	33
	9mm Luger Federal HST 147gr	28
	9mm Luger Federal Hydra-Shok Deep 135gr	20
	9mm Luger +P+ Federal Hydra-Shok 124gr	31
	9mm Luger Federal EFMJ 105gr	39
	9mm Luger Fiocchi EMB 92gr	41
	9mm Luger Hornady Critical Defense 115gr	33
	9mm Luger Hornady Critical Duty 135gr	21
	9mm Luger Hornady XTP 124gr	25
	9mm Luger Hornady AG XTP 124gr	26
	9mm Luger Magtech JHP 115gr	36
	9mm Luger Remington Golden Saber 124gr	25
	9mm Luger +P Remington Gold. Saber 124gr	26
	9mm Luger Speer Gold Dot 115gr	34
	9mm Luger Speer Gold Dot 124gr	29
	9mm Luger +P Speer Gold Dot 124gr	33
	9mm Luger Speer Gold Dot 147gr	22
	9mm Luger Speer Gold Dot G2 147gr	21
	9mm Luger Winchester Defend 147gr	23
	9mm Luger Winchester Ranger Bond. 124gr	35
	9mm Luger +P Winchester Ranger-T 124gr	33
	9mm Luger Winchester Ranger-T 147gr	21
	9mm Luger Average	**29**

	Cartridge	Average kinetic energy transfer ($^{ft\text{-}lbf}/_{inch}$)
Bare gelatin	45 Auto +P Cor-Bon DPX 160gr	42
	45 Auto Federal Guard Dog EFMJ 165gr	51
	45 Auto Federal HST 230gr	27
	45 Auto Federal Per. Def. Hydra-Shok 230gr	29
	45 Auto +P Hornady XTP 230gr	33
	45 Auto Remington Golden Saber 185gr	34
	45 Auto +P Remington Golden Saber 185gr	41
	45 Auto Remington Golden Saber 230gr	25
	45 Auto +P Speer Gold Dot 200gr	54
	45 Auto Speer Gold Dot 230gr	25
	45 Auto +P Speer Gold Dot G2 230gr	23
	Winchester PDX1 Defender 230gr	33
	45 Auto Winchester Ranger-T 230gr	35
	45 Auto +P Winchester Ranger-T 230gr	40
	45 Auto Average	**35**

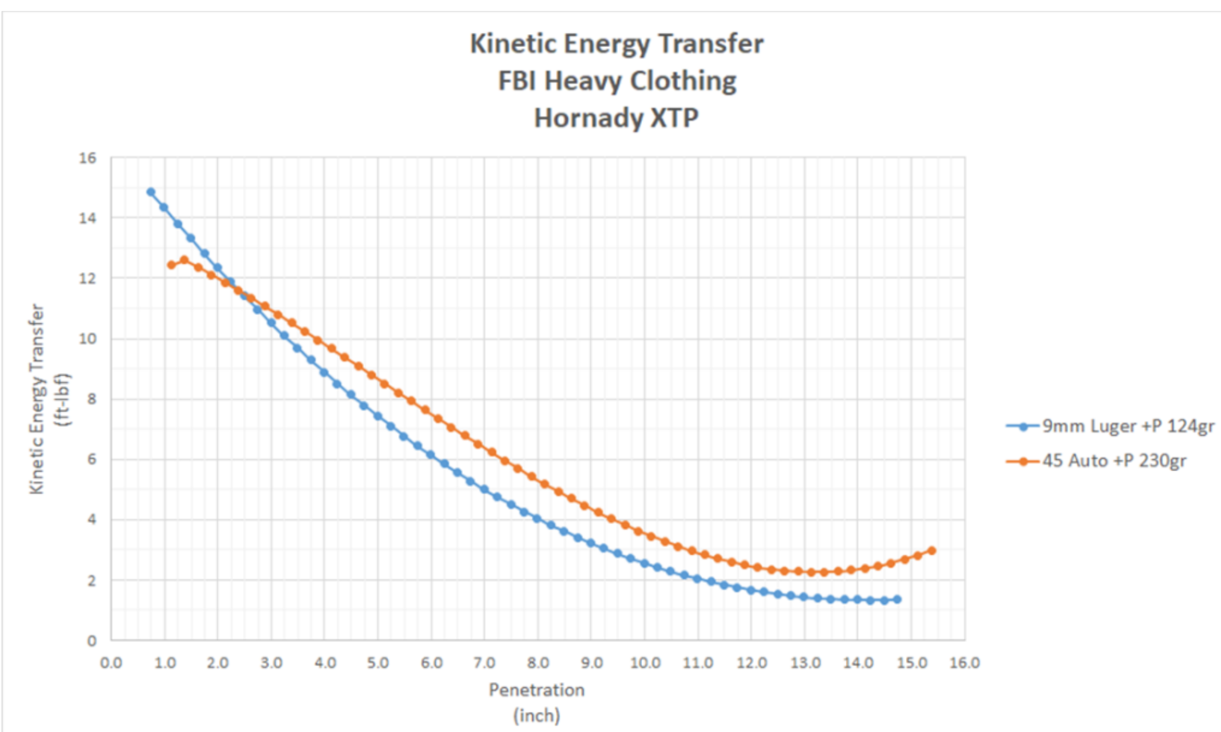
The greater the kinetic energy transfer, the more damage the bullet did to the target. 45 Auto (35 ft-lbf/inch) is superior to 9mm Luger (29 ft-lbf/inch) here as well.

Heavy Clothing



FBI Heavy Clothing setup

Bullets recovered from the FBI Heavy clothing setup



	Cartridge	Average kinetic energy transfer (ft-lbf/inch)
FBI Heavy Clothing	9mm Luger Barnes TAC-XPD 115gr	25
	9mm Luger Federal Hi-Shok 115gr	35
	9mm Luger Federal Hi-Shok 147gr	22
	9mm Luger Federal HST 124gr	27
	9mm Luger Federal HST 147gr	25
	9mm Luger +P+ Federal Hydra-Shok 124gr	36
	9mm Luger Hornady Critical Defense 115gr	32
	9mm Luger Hornady Critical Duty 135gr	20
	9mm Luger Hornady AG XTP 124gr	23
	9mm Luger +P Hornady XTP 124gr	23
	9mm Luger Magtech JHP 115gr	31
	9mm Luger Remington Golden Saber 124gr	24
	9mm Luger +P Remington Gold. Saber 124gr	26
	9mm Luger Speer Gold Dot 115gr	32
	9mm Luger Speer Gold Dot 124gr	28
	9mm Luger +P Speer Gold Dot 124gr	30
	9mm Luger Speer Gold Dot 147gr	22
	9mm Luger Speer Gold Dot G2 147gr	20
	9mm Luger Winchester Defend 147gr	21
	9mm Luger Winchester Ranger Bond. 124gr	30
	9mm Luger Winchester Ranger-T 124gr	27
	9mm Luger +P Winchester Ranger-T 124gr	26
	9mm Luger Winchester Ranger-T 147gr	19
	9mm Luger Average	**26**

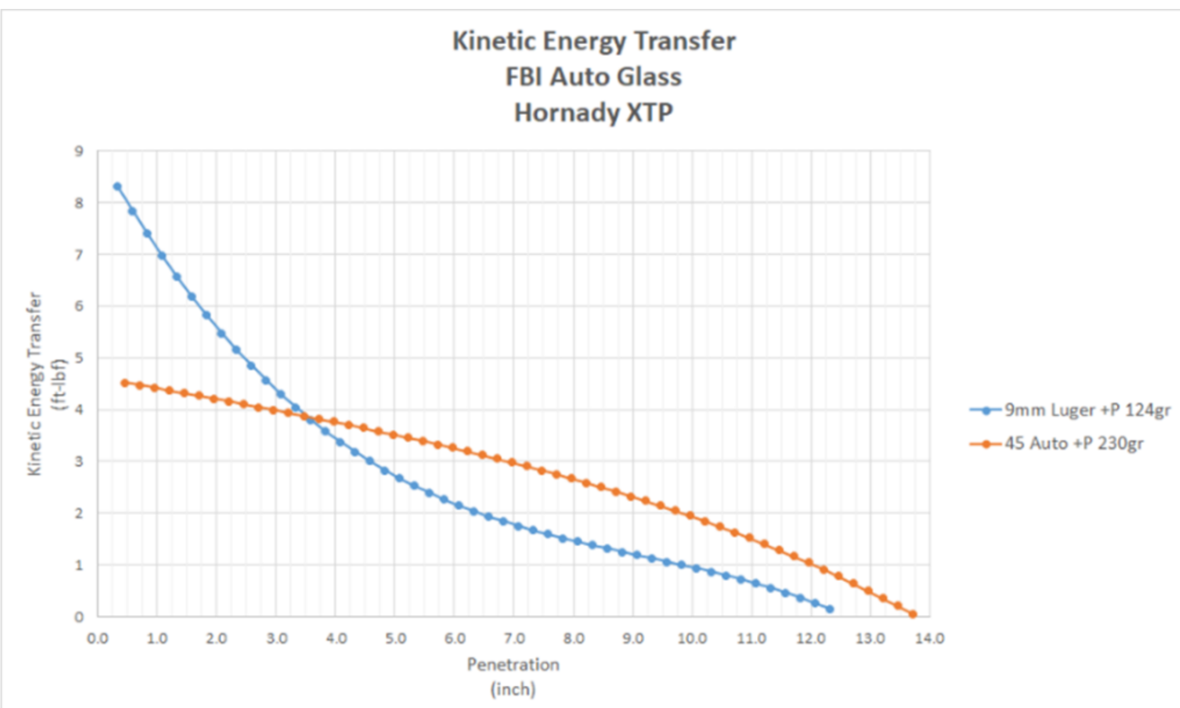
	Cartridge	Average kinetic energy transfer (ft-lbf/inch)
FBI Heavy Clothing	45 Auto Federal HST 230gr	29
	45 Auto +P Hornady XTP 230gr	26
	45 Auto Remington Golden Saber 185gr	30
	45 Auto Remington Golden Saber 230gr	25
	45 Auto Speer Gold Dot 230gr	22
	45 Auto +P Speer Gold Dot G2 230gr	27
	45 Auto Winchester PDX1 Defender 230gr	25
	45 Auto Winchester Ranger-T 230gr	21
	45 Auto Average	**26**

It's a tie between 9mm Luger and 45 Auto here. Because the vast majority of law enforcement ammunition purchases over the last 30 years have been for 40 S&W and 9mm Luger, it is no surprise that 45 Auto bullets have not gotten as much R&D money as these other two. It takes lots of R&D work to get a bullet to expand as reliably in heavy clothing as it does in bare gelatin. Hollowpoints that clog with skin (all of them) closely resemble bullets shot through heavy clothing and recovered from gelatin. Heavy clothing performance is important for this reason.

Auto Glass

FBI Auto Glass setup

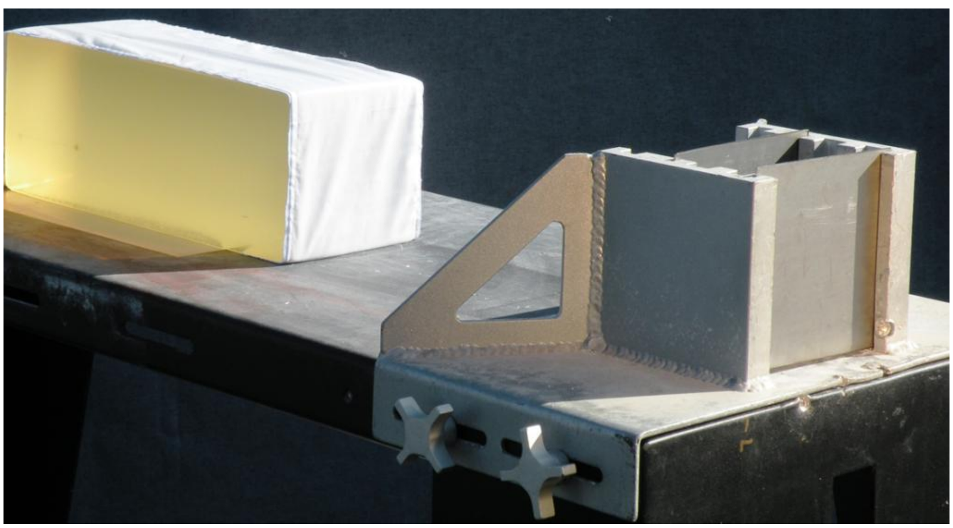
Bullets recovered from the FBI Auto Glass setup



Bullets do unpredictable things when they are shot into solid objects. Pistol bullets lose up to 33% weight and 66% kinetic energy going through auto glass. Shot trajectories take random paths after hitting glass. Shooting through auto glass is a solution of last resort.

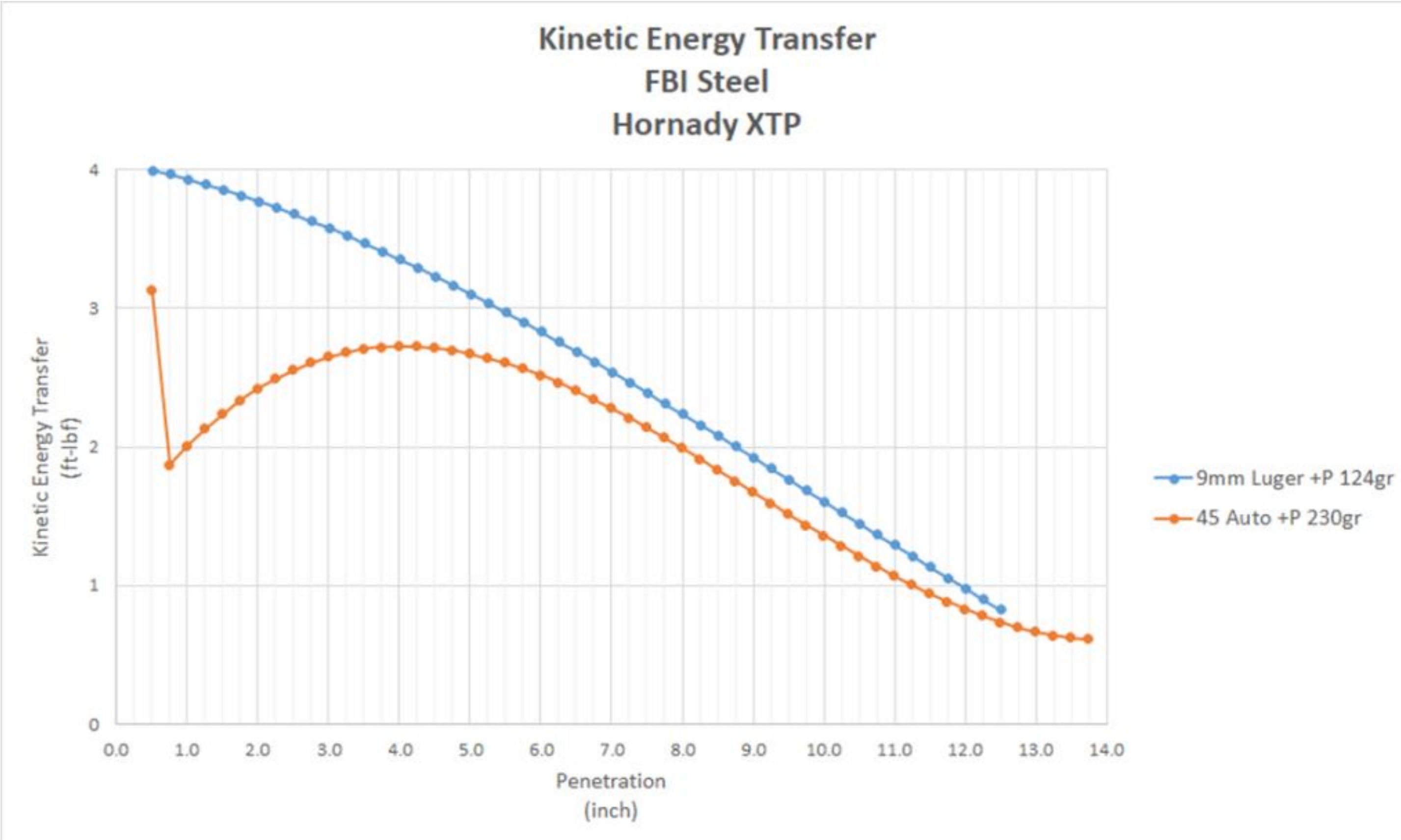
	Cartridge	Average kinetic energy transfer ($^{ft\text{-}lbf}/_{inch}$)
FBI Auto Glass	9mm Luger Hornady AG XTP 124gr	20
	45 Auto +P Hornady XTP 230gr	24
	9mm Luger Remington Golden Saber 124gr	21
	45 Auto Remington Golden Saber 230gr	20
	9mm Luger +P Winchester Ranger-T 124gr	27
	45 Auto Winchester Ranger-T 230gr	30
	9mm Luger Speer Gold Dot G2 147gr	25
	45 Auto +P Speer Gold Dot G2 230gr	28
	9mm Luger Average	**23**
	45 Auto Average	**26**

FBI Steel



FBI Steel setup

Bullets recovered from the FBI Steel setup

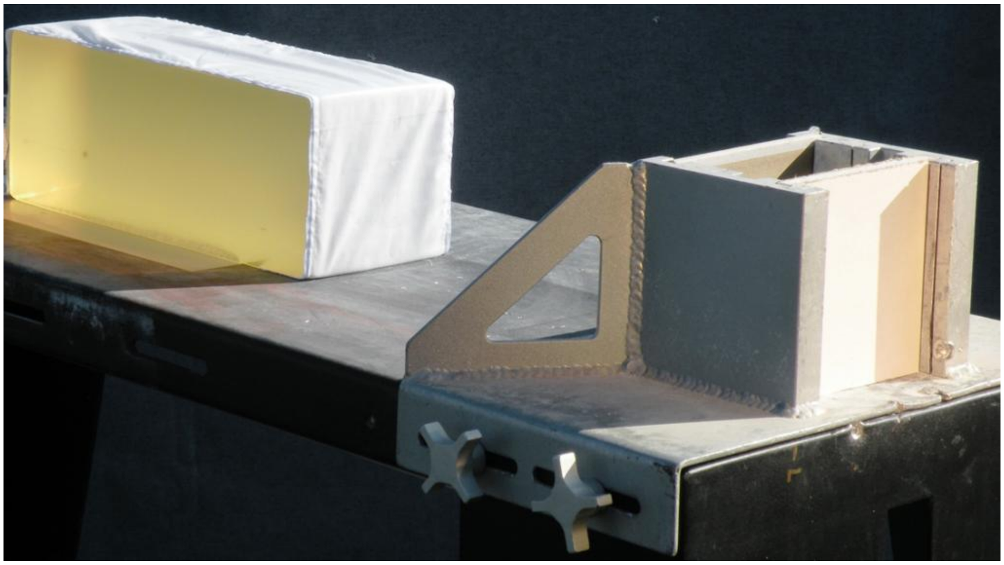


Bullets striking sheet metal will 'nailhead' instead of expand as the ogive is smashed into the shank. In the instance above the 9mm XTP nailheaded more than 45 Auto XTP which also lost 18% weight, which is unusual in this barrier. Generally, though, 45 Auto is superior to 9mm Luger in sheet metal.

	Cartridge	Average kinetic energy transfer ($^{\text{ft-lbf}}/_{\text{inch}}$)
FBI Steel	9mm Luger Hornady AG XTP 124gr	25
	45 Auto +P Hornady XTP 230gr	27
	9mm Luger Remington Golden Saber 124gr	17
	45 Auto Remington Golden Saber 230gr	19
	9mm Luger +P Winchester Ranger-T 124gr	16
	45 Auto Winchester Ranger-T 230gr	20
	9mm Luger Speer Gold Dot G2 147gr	23
	45 Auto +P Speer Gold Dot G2 230gr	28
	9mm Luger Average	**20**
	45 Auto Average	**24**

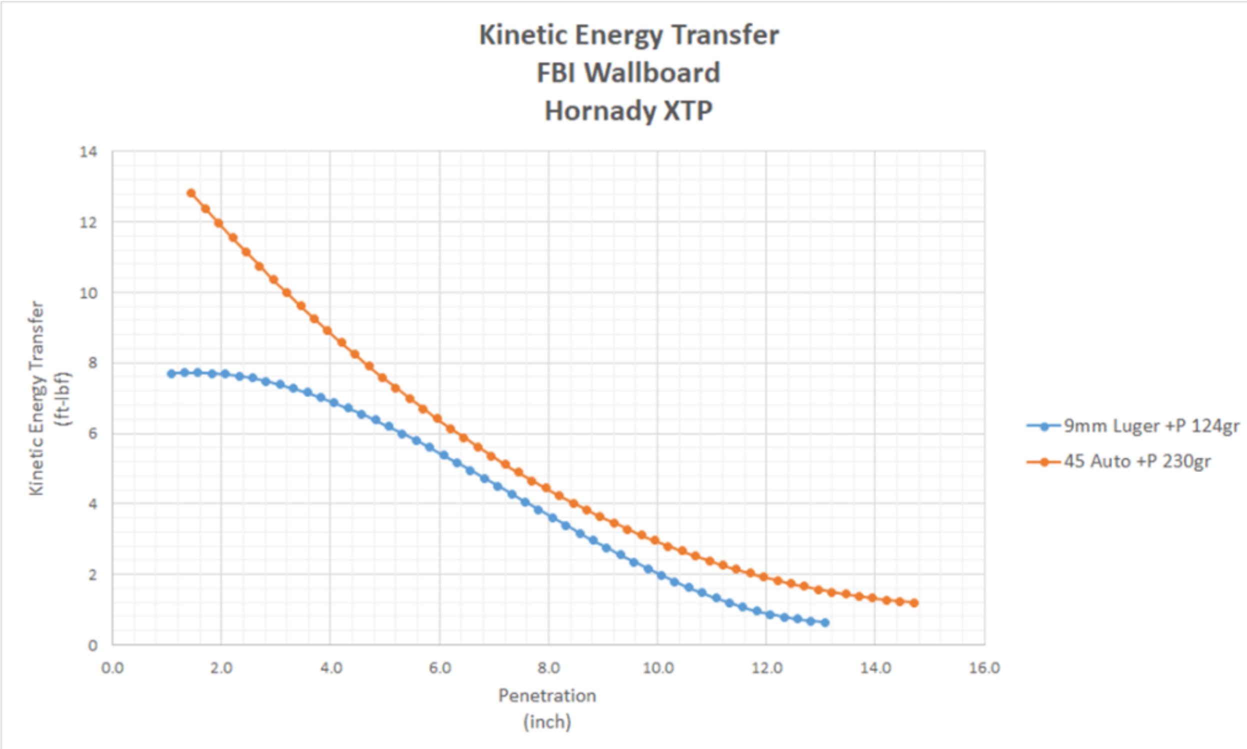
FBI Wallboard

At some point, apparently, a requirement arose to shoot pistol bullets blindly through the interior walls of houses. This test is not to assess safety to bystanders in case of a miss – hollowpoints do not expand in interior walls, they expand in the gelatin block.



FBI Wallboard setup

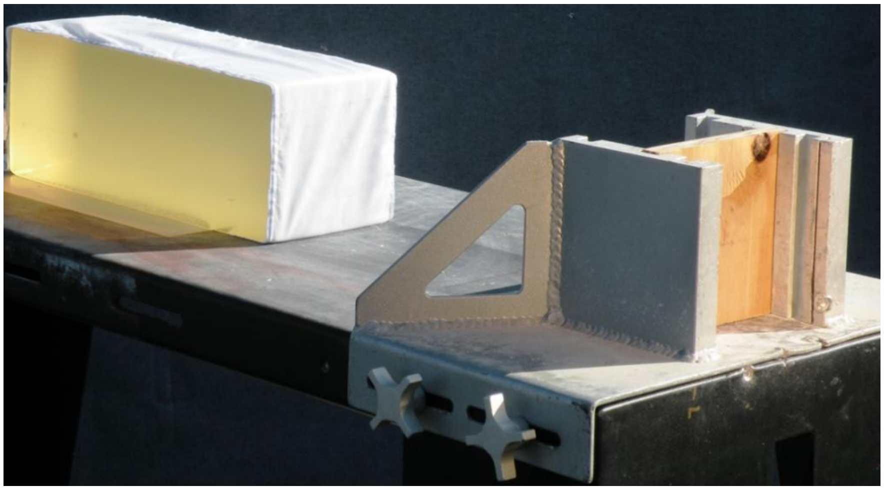
Bullets recovered from the FBI Wallboard setup



	Cartridge	Average kinetic energy transfer ($^{ft\text{-}lbf}/_{inch}$)
FBI Wallboard	9mm Luger Hornady AG XTP 124gr	27
	45 Auto +P Hornady XTP 230gr	29
	9mm Luger Remington Golden Saber 124gr	26
	45 Auto Remington Golden Saber 230gr	26
	9mm Luger +P Winchester Ranger-T 124gr	30
	45 Auto Winchester Ranger-T 230gr	39
	9mm Luger Speer Gold Dot G2 147gr	22
	45 Auto +P Speer Gold Dot G2 230gr	27
	9mm Luger Average	**26**
	45 Auto Average	**30**

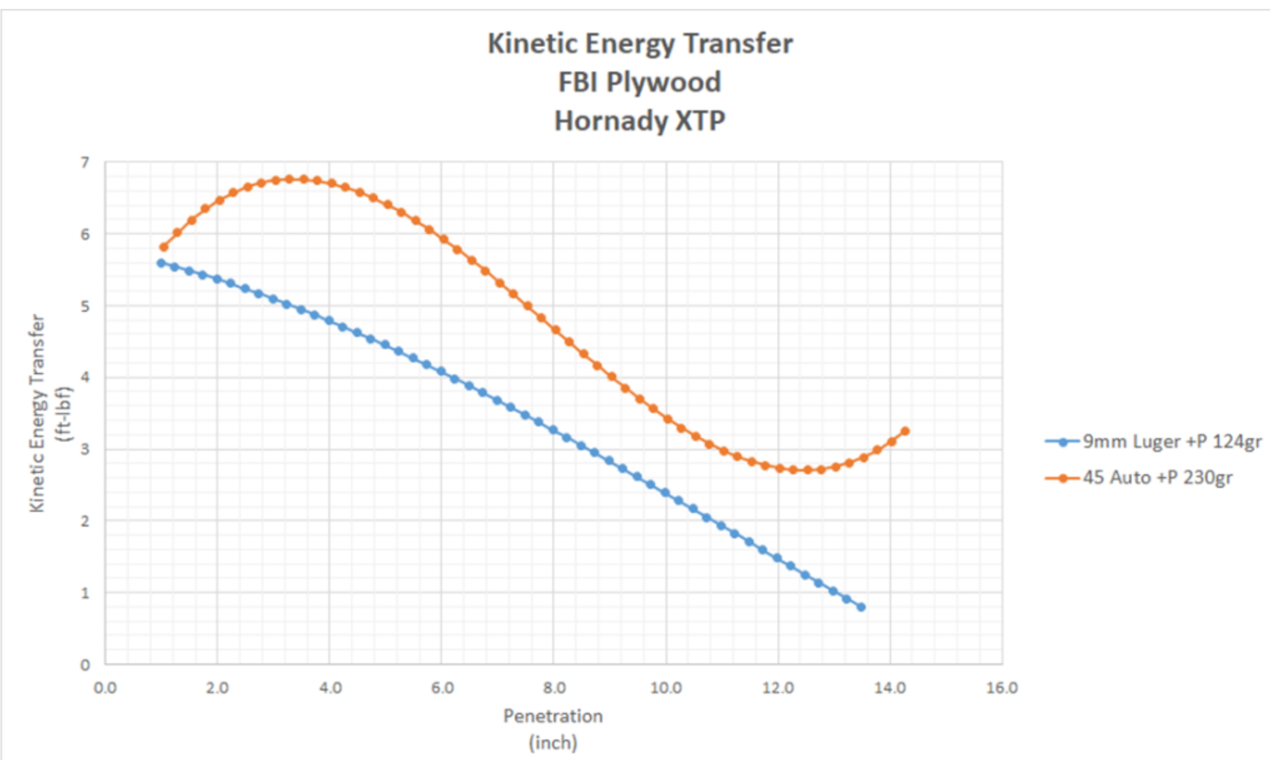
Advantage 45 Auto.

FBI Plywood



FBI Plywood setup

Bullets recovered from the FBI Plywood setup



The 45 Auto XTP failed to expand and immediately destabilized. This is not typical JHP performance in plywood as the majority of JHPs will at least partially expand in gelatin.

	Cartridge	Average kinetic energy transfer ($^{ft\text{-}lbf}/_{inch}$)
FBI Plywood	9mm Luger Hornady AG XTP 124gr	26
	45 Auto +P Hornady XTP 230gr	22
	9mm Luger Remington Golden Saber 124gr	22
	45 Auto Remington Golden Saber 230gr	20
	9mm Luger +P Winchester Ranger-T 124gr	27
	45 Auto Winchester Ranger-T 230gr	24
	9mm Luger Speer Gold Dot G2 147gr	24
	45 Auto +P Speer Gold Dot G2 230gr	24
	9mm Luger Average	**25**
	45 Auto Average	**23**

As a hollowpoint bullet needs to be designed to spit the plug of plywood out by the time it has traveled the 18 inches between the plywood and the gelatin block, the benefit of increased R&D spending on 9mm Luger bullets becomes obvious with this barrier test.

45 Auto 200gr JHP after impact with plywood barrier (plywood plug circled in red)

Advantage 9mm Luger.

Conclusion

45 Auto cartridges offer superior terminal performance to 9mm Luger cartridges shooting expanding bullets. This is applicable to a full-size 45 Auto with a 5” barrel and a 9mm Luger with 4” barrel. These are the barrel lengths that SAAMI members use for their ammunition development and production control. We gave the bullets the best chance to work well by using the barrel lengths they were designed in. Larger diameter pistol bullets will cause more effective wounds.

Consider going back to 40 S&W in favor of 9mm Luger and going with 45 Auto if you are willing to carry a larger firearm that holds less ammunition. Unless you are covered by qualified immunity, you should not be considering a handgun bullet for its barrier performance (bare gelatin and heavy clothing are what matters most, everything else is a fringe benefit) nor considering a gun for its magazine capacity (with the tendency towards 'spraying-and-praying' a higher capacity tends to cause.)

Go with the largest diameter and most energetic cartridge that you can shoot well. There are no points awarded in a fight for ineffective shots. Weigh the time and effort you can spend practicing against the controllability of the biggest gun that you can carry. Shoot a police qualification with a full-size 45 Auto. If you can pass the qualification, the next logical step upward is 45 Super. Unfortunately, 45 Super is not a SAAMI cartridge and is currently only loaded by two manufacturers using bullets with sub-optimal terminal performance for that platform. It would be the best choice for self-defense if loaded with the Barnes TAC-XPD 185gr bullet. What should happen once you qualify with the full-size 45 Auto is to decide to stay with that setup or keep the cartridge and move down in gun size to increase comfort carrying concealed. Remember that you pay for what you get. Barrels get shorter as guns get smaller. Shorter barrels lead to less velocity and less velocity means less bullet expansion so lesser terminal performance.

Shoot the qualification again with a compact 45 Auto, then a subcompact. If you can pass qualification with all of these, then your options are broad. Try to step up to 45 Super in any of these platforms. If you cannot qualify with a full size 45 Auto pistol, you should seek additional firearms training. A logical starting point if 45 Auto is not an option is a 40 S&W full size handgun and then repeat the qualifications with guns of decreasing size. 9mm Luger is most advantageous when up-gunning the smallest of concealed handguns from 380 Auto. Both use the same diameter bullets but the two cartridges are in a different category from each other in terms of terminal performance. Be aware that a sub-compact 9mm Luger handgun is an expert's gun – the discomfort of shooting such guns discourages training, which is most needed with these given the diminutive cartridge and small control surfaces.