Ballistic gelatin comparisons: Part I

Is clear, synthetic gelatin an acceptable substitute for FBI-standard, 10% calibrated gelatin?

Nov 11, 2019

Until the early 1990s, there was no accepted industry standard for evaluating the terminal ballistic performance of duty handgun ammunition for law enforcement. As a result, agencies that wanted to conduct an objective examination of duty ammunition were forced to develop their own test protocols and standards, or rely on the data provided by manufacturers or other agencies (frequently federal agencies, since they had the budgets to do this kind of testing).

A significant limitation of this approach is that it was impossible to compare data from different sources. Every test differed from the next and introduced variables, assumptions and theories that made direct comparisons of the data fruitless. For example, differences in test mediums (water jugs, clay, gelatin of different concentrations and temperatures), pet ballistic theories (temporary cavities versus permanent cavities, "energy dump" versus penetration), and desired performance (penetration depth, expansion, retained weight, cavity measurements) made each set of data individually unique and incomparable.

To illustrate, it's useful to consider the critical variable of penetration depth, which was measured and rewarded in very different ways in major studies from the 1970s through the early 1990s. In National Institute of Justice testing, bullets were evaluated and scored on their ability to penetrate between 1.6 and 8.7 inches in the test media (20% gelatin), while US Secret Service testing focused on the 1–5.9 inch range (20% gelatin), US Navy testing focused on the 7–12 inch range (20% gelatin), and US Immigration and Naturalization Service testing favored performance in the 9–12 inch range (10% gelatin). Based on this factor alone, it's easy to see how a bullet that scored highly in one test could fail the test conducted by another agency.

 With the introduction of a new, clear, synthetic "gelatin" product to the market, standardization could be in jeopardy. (Photo/Mike Wood)

SETTLING ON A STANDARD

When the Federal Bureau of Investigation (FBI) introduced its own standards for terminal ballistic performance in December 1988, they were met with a mix of enthusiasm and resistance. In fairness, there were things to both like and dislike about the FBI standards in their first iteration, but over the course of time, "the protocol" – and, more importantly, the interpretation of the data derived from the protocol – has improved and matured to the point that it's now the uncontested industry standard.

The protocol has been widely accepted by both the law enforcement and manufacturing communities and has given them a standard to work from. The FBI protocol has established a common language, a standardized testing process and standardized benchmarks for performance that have allowed a variety of different agencies, companies and individuals to conduct their own testing and contribute data that is directly comparable to the data derived from other tests and sources.

This has been a positive influence on the development of duty ammunition. The improvements in communication and information sharing have led to the development of several new generations of duty ammunition that were designed to excel in the stages of the FBI protocol.

The first generation of FBI protocol-inspired bullets – represented by designs such as the Federal HST, Hornady XTP, Remington Golden Saber, Speer Gold Dot and Winchester SXT – dramatically improved the capabilities of law enforcement ammunition. However, a desire for "barrier-blind" bullets that offered more consistent performance after encountering the intermediate barriers of the FBI protocol has led to an even more advanced second generation of bullets, typified by designs such as the Hornady Critical Duty Flexlock bullet, Speer G2 Gold Dot bullet and Winchester Ranger One bullet. Absent the FBI protocol, and its influence on bullet development, it's doubtful that law enforcement officers would have access to such innovative and capable duty ammunition today.

FULL CIRCLE

In an interesting twist though, the law enforcement community is currently in danger of repeating some of the mistakes of the period that predated the adoption of the FBI protocol. Specifically, they are in jeopardy of returning to the time when data sets were not comparable, due to the choice of different test mediums.

Before the FBI standardized the use of (nominal) 10%, calibrated, ballistic gelatin, various groups used materials as disparate as wet newspaper, clay, water jugs, ballistic soap (still popular in Europe), or 20% ballistic gelatin (favored by the US military), shot at a variety of temperatures, to test ammunition performance. Since the widespread adoption of the FBI protocol however, all serious testing done in the United States has been conducted with organic gelatin prepared according to FBI specifications, promoting a high degree of standardization.

Now, with the introduction of a new, clear, synthetic "gelatin" product to the market, this standardization is potentially in jeopardy.

CHOOSING YARDSTICKS

One of the problems with FBI-standard gelatin is that it's fairly labor-intensive to prepare, store, transport and maintain during testing. The organic gelatin must be carefully prepared to obtain the proper density, stored at low temperature (around 40 degrees F), and shot while the gelatin is still cold. The gelatin must be calibrated by the user (by firing a 0.177" steel BB into the gelatin at a velocity of 590 +/- 15 feet per second, and checking for penetration depth between 2.95 – 3.74 inches) immediately before it is used, and rejected if it fails. The gelatin deteriorates quickly, is temperature sensitive and can be messy to work with.

The hassle of working with properly prepared ballistic gelatin has encouraged the introduction of a clear, synthetic product that's easier to work with. The new, synthetic product comes prepackaged, requires no "assembly," has a calibration "guarantee" from the factory, isn't as sensitive to sunlight, rain, or temperature, and isn't as messy as calibrated, 10% organic gelatin. It's also clear, instead of the hazy straw or amber color of 10% organic gelatin, which allows the wound tracks in the synthetic product to be more easily seen and photographed from outside the block. These significant advantages make it a very attractive alternative to FBI-standard gelatin, and many commercial businesses and public safety agencies have begun to substitute it for FBI-standard gelatin in their own testing.

THE QUESTION

The question that remains is whether the new synthetic product is a viable substitute for the FBI-standard gelatin.

If the clear synthetic product performs identically to 10% calibrated gelatin, then test results derived from the new product can be evaluated using the FBI's criteria for ammunition performance without issue.

However, if the synthetic product has different qualities than 10% calibrated gelatin, and the ammunition fired into it behaves differently, it's both inappropriate and misleading to judge the performance of the ammunition using FBI guidelines. In an "apples to oranges" comparison such as this, it's possible that a law enforcement agency could "fail" a round that would normally pass the FBI's demanding protocol when it was fired into FBI-standard gelatin, or "pass" a round that would normally fail the FBI's protocol. In either case, the agency might choose a round that is inappropriate for their mission, and endanger the safety of their personnel and the public.

WARRANTIES, GUARANTEES AND QUESTIONS

The manufacturer of the clear synthetic product guarantees that their product meets FBI specifications, and is therefore a viable substitute for 10% calibrated gelatin.

The manufacturer conducts random testing on every batch of synthetic gelatin they produce. Sample blocks from each production run are tested by shooting a 0.177" steel BB into the gelatin at a velocity of 590 +/- 15 feet per second, as specified by the FBI. If the selected sample block meets penetration specifications, then each block in the batch is considered to have passed calibration. A warranty card is included with each of the untested blocks that lists the penetration of the BB in the tested sample, assuring the end-user that their block from the same batch meets FBI specifications (BB penetration depth between 2.95–3.74 inches).

A sample-based calibration guarantee from the manufacturer is nice, but the FBI protocol requires each individual gelatin block to pass calibration prior to testing. If the actual block is not verified to be within limits, the validity of the data derived from that block would be in question. Therefore, despite the manufacturer's guarantee, the calibration of the synthetic gelatin blocks must be verified by the user, prior to shooting them.

In early 2018, I was approached by industry professionals with concerns that the clear synthetic gelatin was not passing FBI calibration in their independent testing. Despite the guarantees provided by the manufacturer that their synthetic product performed similarly to 10% calibrated gelatin, it appeared that calibration BBs were penetrating beyond the maximum depth allowed by the FBI. It also appeared that ammunition fired into the synthetic material was performing differently than it normally did in 10% calibrated gelatin, with projectiles under expanding and over penetrating in the new, synthetic product.

PRELIMINARY RESEARCH

As a result of these concerns, I began to collect and compare data on ammunition tests in both mediums.

Unfortunately, there was no entity that had tested both mediums with the same projectiles. Ammunition manufacturers, law enforcement agencies, private citizens and commercial businesses had all tested ammunition in either 10% calibrated gelatin or the clear synthetic gelatin, but none of them had tested the same ammunition in both products.

As a result, I was left to compare data from different sources, with no assurance that the test methods and environmental conditions were consistent between the data sets. Despite this limitation, the publicly available data seemed to indicate a discrepancy between the performance of selected models of handgun ammunition fired into the two test mediums. The reported concerns about performance differences in 10% calibrated gelatin and clear synthetic gelatin seemed to be supported by the available data.

Chronographing the BB gun at the test facility, prior to firing calibration shots into the gel. (Photo/Mike Wood)

TEST PLAN

In late 2018, I began to coordinate with a number of ammunition manufacturers to develop a plan for comparing the clear synthetic product and 10% calibrated gelatin in a fair test, to determine if there was a true and meaningful difference between the two products. In order to eliminate variables, the two products would be tested at the same facility, in the same environmental conditions, using the same protocols, weapon and box of ammunition.

The manufacturer of the clear synthetic product was also consulted and brought into the planning effort. With their support and the support of several ammunition companies, I began to prepare for the comparison test.

Coordination continued throughout the early part of 2019, and by early August, the test had been completed.

The data derived from this test is important. For the first time, the two products have been tested by a single source, under identical conditions, using identical methods. This comparison will allow industry and law enforcement to determine whether the clear synthetic gelatin is an acceptable substitute for FBI-specified, calibrated gelatin.

The details of how the test was conducted is discussed in Part II.

Ballistic gelatin comparisons: Part II

A variety of bullet weights, velocities, pressure levels, styles and designs were represented in the data, to ensure the broadest comparison of the two test mediums

Dec 17, 2019

In Part I of this series, we discussed how concerns of inconsistencies between the performance of handgun ammunition in FBI-standard ballistic gelatin and the new, clear synthetic gelatin that's becoming increasingly popular, encouraged a comparison test of these two mediums.

Since there was mounting evidence that some law enforcement agencies were using results obtained from the new, synthetic product to make duty ammunition choices, it was important to verify whether those results could be evaluated according to FBI performance standards that were developed using 10%, calibrated organic gelatin.

Would the synthetic gelatin product perform close enough to the organic gelatin that the data obtained in the two mediums would be directly comparable in an “apples to apples” fashion, or would differences in the two test mediums turn things into an “apples to oranges” comparison?

 Meticulous records were kept during all phases of testing, documenting velocities, penetration depths, expansion and retained weight. (Photo/Mike Wood)

SMALL-SCALE TESTING

To answer that question, I worked with Hornady Manufacturing Company representatives to design a comparison test of the two mediums.

Before we committed resources to a large-scale test, we began with a small-scale test that compared the performance of Hornady’s 9mm +P, 135 grain, Critical Duty Flexlock bullet in the two mediums. If this small test indicated there was a discrepancy, we would proceed with plans for a more exhaustive comparison.

In Hornady’s tests of its 9mm +P, 135 grain, Critical Duty Flexlock bullet, the projectile normally penetrated around 14.5 inches in bare, calibrated gelatin. Independent testing of this projectile by the US Department of Homeland Security (14 inches) and the FBI (14 inches), as well as joint Hornady/agency testing with the Mesa (Arizona) Police Department (14 inches), Nebraska State Patrol (14.75 inches) and the Texas Department of Public Safety (14.25 inches), validated this performance (using a variety of pistol makes and barrel lengths) and confirmed Hornady’s expectation for this projectile.

However, when Hornady tested the same ammunition in the clear, synthetic gelatin substitute (same test protocol and conditions, including barrel length and lack of an intermediate barrier) the 9mm FlexLock bullet penetrated around 19 inches. This represented a 31% increase in penetration in the clear synthetic product compared to FBI-calibrated gelatin.

Additionally, the profile of the wound tracks was different in the synthetic product in comparison to FBI-calibrated gelatin, with an almost nonexistent Maximum Temporary Cavity (MTC)

dimension, and a longer Depth to Maximum Cavity (DMC), followed by an “ice pick” kind of penetration after that.

Based on these initial results, plans were made to proceed with a large-scale comparison test of the two products.

LARGE-SCALE TEST PROTOCOL

It was important to ensure that large-scale testing would be conducted in accordance with standard FBI protocols, with the highest measures of quality control and consistency, to develop a useful set of data for comparison.

This meant a professional facility would be required for testing. While there are many “backyard ballisticians” who prepare and shoot organic gelatin, such settings can introduce variables that will skew data. For instance, since organic gelatin is highly sensitive to temperature and can break down quickly in heat and direct sunlight, it must be carefully preserved at consistently low temperatures and shot for record before it warms. It’s difficult to maintain these temperatures when a block must be transported to an off-site test facility in a cooler, and shot in warm, ambient conditions – perhaps even in direct sunlight. It’s even more difficult to do this with multiple blocks and keep them all at a consistent temperature for reasonable comparison to each other. Spread the testing process out to multiple days, and the consistency challenge becomes even more complex.

The two-day test would be conducted at the same facility that Hornady uses for internal research and quality control testing, as well as testing for its extensive list of law enforcement, military and industry clients. This environmentally controlled facility would allow for consistent and measurable conditions and would allow access to calibrated equipment for measuring bullet velocities and weights. Organic gelatin blocks could be preserved at ideal and consistent temperatures in nearby industrial refrigeration units until they were removed for immediate testing, conducted only yards away.

All gelatin blocks – both organic and synthetic – would be tested for calibration in accordance with FBI standards, immediately prior to shooting. This test would involve firing a 0.177” steel BB into the gelatin at a measured velocity of 590 +/- 15 feet per second, and checking for penetration depth between 2.95 – 3.74 inches. Any organic gelatin block that failed to meet these calibration standards would be rejected to ensure the synthetic product was only compared to FBI-spec ballistic gelatin.

A single pistol (same serial number) would be used to conduct all testing for consistency. The Glock 17 was chosen as it is the most widely used 9mm service pistol in U.S. law enforcement. The test pistol was a Glock 17M model, as currently issued by the FBI.

In order to generate a data set that was not limited to Hornady products, the author solicited assistance from other major ammunition manufacturers to supply product samples. Law enforcement duty ammunition was received from both Speer and Federal in response to this request. Winchester and Remington were unable to supply samples, so the author purchased

ammunition from these marques via commercial channels, to ensure they would be represented in the data.

A variety of bullet weights, velocities, pressure levels, styles and designs were represented in the data, to ensure the broadest comparison of the two test mediums. “Barrier blind” bullets from Hornady (Critical Duty 124+P and 135+P) and Speer (147 grain G2) were included, as well as advanced hollowpoint designs from Federal (124 grain HST) and Winchester (127+P+ Ranger SXT). A “low-tech” traditional jacketed hollowpoint from Remington (115+P HTP) was also tested to help broaden the selection.

The synthetic gelatin was sourced from a commercial vendor and the order was filled and shipped to Hornady by the manufacturer, who had been fully briefed that the blocks would be used in this testing.

The organic gelatin was prepared in accordance with FBI instructions. The blocks that were shot on the first day of testing were prepared in advance of the author’s arrival by Hornady personnel, and the author personally prepared the blocks which were used on the second day of testing.

Two individuals – one from Hornady and the author – would take all the measurements, and compare results with each other to identify errors and correct discrepancies before the final results were recorded.

AN ADDITIONAL QUESTION

It’s important to understand that the FBI specifications for gelatin calibration constitute a range of acceptable penetration depths for the test BB projectile. This is because organic gelatin may demonstrate slight variations in density as a result of mixing ratios, environmental humidity and the source of the organic gelatin itself. Additionally, the density may change slightly as the core temperature of the gelatin varies between acceptable extremes.

The FBI has determined that organic gelatin will provide useful and comparable results as long as the 0.177” calibration BB penetrates to a depth between 2.95–3.74 inches. Anything on either side of this band is considered unacceptable for measuring bullet performance in accordance with FBI standards for penetration, expansion and retained weight.

In order to provide the fairest comparison for the synthetic gelatin, it was important to quantify the performance change between bullets that were fired into “minimum spec” FBI gelatin and “maximum spec” FBI gelatin. This would allow us to compare the synthetic results to the full range of acceptable measures from organic gelatin, mixed in accordance with FBI standards.

To determine this difference, the ratio of organic gelatin powder to water was slightly altered to create gelatin blocks that would calibrate at both the high and the low ends of BB calibration. The “minimum spec” block we prepared calibrated at 3.00” and the “maximum spec” block calibrated at 3.625” when tested with the 0.177” BB, which was about as close as you could get to the FBI goalposts.

Sometimes, bullets would not stay inside a single block, and had to be recovered from a secondary block behind the first. (Photo/Mike Wood)

Three rounds each of Hornady 124+P and 135+P Critical Duty were fired into the minimum and maximum blocks, then measured. Retained weight was 100% in both blocks for all 12 rounds, and there was negligible difference in expanded diameter between them (an average of 0.005" more expansion – less than a 1% difference – for rounds fired into the minimum block). However, the penetration distance changed about 1.25" for the 135+P and about 0.42" for the 124+P between the minimum and maximum block. These distances were slightly longer than those noted in previous testing conducted by Hornady, using industry-standard 5 round samples

(in lieu of our abbreviated 3 round samples), which revealed a 1.00” maximum (typically, less than 1.00”) difference between gelatin that calibrated at the minimum and maximum FBI specs.

From this, we conservatively concluded that any variation in penetration of less than 1.5” (including a generous 0.25” buffer over the already high 1.25” maximum average penetration observed in our 3-round test) in the synthetic gelatin could be ignored as statistically insignificant. Restated, if bullets penetrated 1.5” more in the synthetic gelatin than in the calibrated organic gelatin, we would judge the synthetic results as comparable to the organic medium.

SHOTS FIRED

Armed with this knowledge, and with a protocol that maximized consistency and repeatability, we began to shoot synthetic and organic gelatin with the selected ammunition.

Ambient temperature on the indoor range was 70-72 degrees, and organic gelatin blocks were kept at 38 degrees in a commercial refrigerator until they were taken out for calibration and testing, which occurred within minutes of removing them from the refrigerator. The synthetic gelatin blocks were stored on the range overnight and were kept at the 70-72 degrees ambient temperature of the range.

The organic and synthetic blocks were shot with 3 rounds each of the 6 models of ammunition (2 from Hornady, and 1 each from Speer, Federal, Winchester and Remington). In accordance with the FBI protocol, the blocks were shot at a distance of 10 feet from the muzzle of the Glock 17M pistol to the front face of the gelatin.


The heavy clothing testing was conducted in accordance with FBI standards, using materials that met FBI specifications. (Photo/Mike Wood)

Each test medium was shot in accordance with Tests One and Two of the FBI protocol. In Test One, bullets are fired into bare gelatin, and in Test Two, the gelatin blocks are covered with FBI-standard “heavy clothing,” which consists of four layers of material, to include:

- One layer of cotton t-shirt material (approximately 5.25 ounces per yard, 48 threads per inch);

- One layer of cotton shirt material (approximately 3.5 ounces per yard, 80 threads per inch);
- One layer of Malden Mills Polartec 200 fleece, and;
- One layer of cotton denim (approximately 14.4 ounces per yard, 50 threads per inch).

OBSERVATIONS

The results and implications of this test will be discussed in the final segment of this series.

Ballistic gelatin comparisons: Part III

There's a clear difference between synthetic and organic gelatin that law enforcement needs to understand

Jan 7, 2020

In Part I of this series, we talked a little bit about the history of ballistic testing since the 1970s, and how the FBI's efforts after the 1986 Miami gunfight helped to create a national standard for testing law enforcement handgun ammunition. That standard, now referred to as the "FBI protocol," established a clear and repeatable process for testing ammunition in 10% calibrated gelatin, and defined a set of parameters for law enforcement duty ammunition performance that rapidly became the profession's yardstick.

It's significant that the FBI protocol provided standardization where there was none before. Before the protocol was developed, each law enforcement agency and manufacturer drafted their own standards for ballistic testing and used a variety of test mediums in their evaluations. With the widespread adoption of the protocol and 10% calibrated gelatin as a test medium, law enforcement and industry now had a single, repeatable, comparable process for testing duty ammunition.

In Part II, we discussed how this industry standardization is potentially in jeopardy from a new and popular ballistic test medium, made of a clear synthetic. Small scale testing indicated that bullets fired into the clear synthetic product were performing differently than they did in the FBI-specified, 10% calibrated gelatin, making it inappropriate to measure their performance with the FBI yardstick.

 There were two significant findings from this test. (Photo/Mike Wood)

As a result of this apparent discrepancy, plans were made to conduct a thorough test of the clear synthetic test medium to verify whether it gave comparable results to 10% calibrated gelatin. We discussed the details of the test plan in Part II, and now it's time to discuss the results.

THE BOTTOM LINE, UPFRONT

There were two significant findings from this test.

First, none of the factory fresh, clear synthetic blocks passed FBI calibration, despite the fact that the included warranty cards indicated they would. Each of the four new blocks had warranty cards that indicated that calibration BBs had penetrated 3.5 inches in sister samples from the same lot, but when we tested the blocks, we recorded BB penetrations ranging between 4.625" and 4.875". Due to the elastic nature of the material, the BB would penetrate, then spring back to a final resting place that was short of the overall penetration depth (the same happens in organic gelatin). The FBI measures the overall penetration depth, but even the shorter resting distance of our calibration BBs ranged between 4.0" and 4.125" in the clear blocks, which is beyond the FBI's acceptable maximum overall penetration of 3.74".

Second, our test of six different 9mm cartridges from five different manufacturers indicated that bullets tend to under expand and over-penetrate in the clear synthetic gelatin, compared to 10% calibrated gelatin. There was an insignificant difference in retained weight between the two test mediums, with the bullets fired into the clear synthetic losing the smallest fraction of their weight.

These tendencies were the same for bare gelatin and gelatin covered with FBI-standard "heavy clothing." They were the same for all tested variations of bullet weight, velocity and construction, as well.

As seen here, the calibration BBs bounce back in the clear synthetic gelatin, just as they do in 10% organic gelatin. Unfortunately, the overall penetration of the BB in the clear synthetic exceeds FBI standards. (Photo/Mike Wood)

BY THE NUMBERS

To help quantify these differences, we'll compare how a particular bullet design performed in both test mediums, in terms of penetration, expansion and retained weight. There will be no attempt to compare one cartridge to another since it was not our objective to compare ammo. Our task was solely to compare how the clear synthetic gelatin stacked up against 10% calibrated gelatin as a test medium, so each bullet will only be judged on how it performed against itself in the two test mediums, and values will be expressed as percentages, instead of raw numbers.

EXPANSION

So, let's start with expansion in the bare (uncovered) gelatin. In our test, the sampled bullets expanded less in the bare, clear synthetic gelatin than they did in the bare, 10% calibrated gelatin. The average expansion for all the bullets we tested in the clear synthetic was only 92.2% of what we saw for those same bullets in the 10% calibrated gelatin, with comparable expansion ranging from a low of 89.4% (the standard pressure, 124 grain Federal HST) to a high of 96.7% (the 147 grain Speer G2).

When we added the FBI heavy clothing layer in front of the two gelatin products, the same relationship held true – the bullets fired into the clear synthetic gelatin expanded less than they

did in the organic, 10% calibrated gelatin, giving us only 89.3% of the expansion we saw in the calibrated gelatin, on average. In the heavy clothing test, the lowest clear synthetic expansion we saw was 84.4% of the calibrated gelatin value (the 147 grain Speer G2), and the highest was 92.3% (the standard pressure, 124 grain Federal HST).

Our testing indicates there is something different in the density and/or elasticity of these two types of gelatin that makes bullets expand differently in each of them. The bullets fired into the clear synthetic gelatin expanded around 8% (bare) to 11% (heavy clothing) less, on average, than they did in the organic, 10% calibrated gelatin.

This is a calibration BB fired into one of the 10% organic gelatin blocks. The penetration of this

BB falls between FBI specifications of 2.95 inches to 3.74 inches, as it should. (Photo/Mike Wood)

PENETRATION

With the decreased expansion, it's no surprise that the bullets fired into the clear synthetic gelatin also penetrated further than they did in the organic, 10% calibrated gelatin. Because the smaller surface area of these projectiles created less drag in the clear synthetic than the organic gelatin, the bullets retained more of their energy and went further.

Looking first at the bare gelatin results, on average, the sampled bullets penetrated 35.5% deeper into the clear synthetic product than they did in the organic, 10% calibrated gelatin, with a range between 34.4% (the 135+P Hornady Critical Duty) and 36.3% (the standard pressure, 124 grain Federal HST).

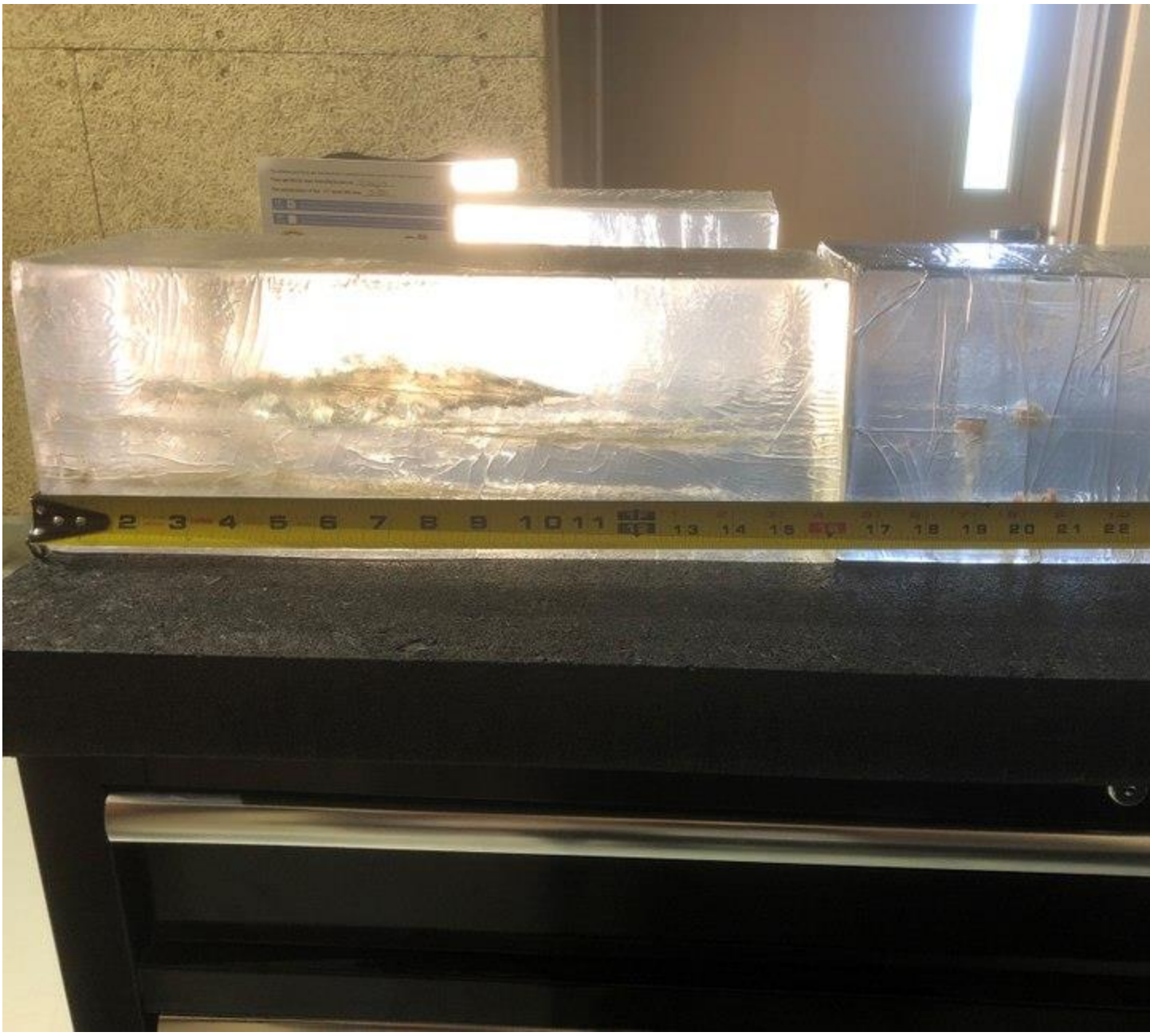
When we added the FBI heavy clothing layer in front, the bullets fired into the clear synthetic continued to penetrate deeper than they did in the organic gelatin, by a startling average of 48.1% for all the tested cartridges. The highest difference in penetration was 56.1% more in the clear synthetic than the organic (the standard pressure, 124 grain Federal HST), and the lowest difference was 38.2% more in the clear synthetic than the organic (the 135+P Hornady Critical Duty).

The percentages are fine, but to put things into better perspective, the 48.1% average increase in penetration for the six loads fired into the clear synthetic gelatin, covered in heavy clothing, represents a little more than 6" of extra penetration in the clear synthetic product, compared to the organic product.

We had previously noted that the makeup and behavior of (nominal) 10% organic gelatin can vary slightly, due to differences in humidity, temperature and the source of the gelatin. As such, the FBI considers organic gelatin to meet calibration standards if a 0.177" BB fired at 590 +/-15 fps penetrates to a depth between 2.95-3.74 inches.

Readers will recall that our prior testing indicated this calibration range could account for as much as a 1.25" difference in penetration distance (typically, less than 1", but we did have a 1.25" data point in our abbreviated, 3-round test) in the organic gelatin, so we allowed for a very conservative 1.5" difference between the clear synthetic gelatin and organic gelatin, to level the playing field.

Even with this 1.5" handicap applied, the bullets fired into the clear synthetic gelatin consistently penetrated farther than they did in the organic gelatin – on the order of about 24% (bare) to 36% (heavy clothing) more, on average.



Bullets fired into the clear synthetic gelatin tended to expand less and penetrate more than they did in 10% organic gelatin. Shown is the 9mm Hornady Critical Duty 135+P. (Photo/Mike Wood)

RETAINED WEIGHT

The bullets fired into the clear synthetic and organic gelatin didn't shed much, if any, of their weight, regardless of whether the gelatin was bare or covered with heavy clothing. However, there was an incredibly minor tendency for the clear synthetic bullets to lose the tiniest bit more weight than the organic gelatin bullets.

In bare gelatin, the bullets fired into the clear synthetic lost only 0.2% more weight, on average, than those fired into the organic gelatin (with a high-low range of 0.1% to 0.4%). When the gelatin was covered with heavy clothing, the bullets fired into the clear synthetic lost only 0.3% more weight, on average, than those fired into the organic medium (with a high-low range of 0.0% to 1.4%).

In the real world, these differences are insignificant and should not influence bullet performance. We're only reporting them here to be thorough, but the takeaway for the reader should be that there is no meaningful difference in retained weight between the clear synthetic and organic, 10% calibrated gelatin products.

TAKING STOCK OF THE TEST RESULTS

It's important that the warranty cards that stated the clear synthetic gelatin blocks had passed FBI calibration standards were not accurate for the four samples we used in our testing. Our calibration BBs penetrated much further in the virgin blocks than the FBI standards allow, providing an early warning that the blocks would not give results comparable to 10% calibrated gelatin, prepared according to FBI specifications.

It's interesting that even after the blocks had been melted down after the first use and reconstituted for a second round of testing (allowable, per the manufacturer), the material continued to fail FBI-standard calibration – although just barely. In our second round of calibration tests, the reconstituted blocks allowed BBs to penetrate between 3.75" and 3.825", which is much closer to the FBI specification than the virgin blocks allowed, but still just beyond the far limit for penetration.

Given that these blocks failed FBI standards for calibration each time, it's unsurprising that the bullets we fired into them penetrated more deeply than they did in 10% calibrated gelatin. However, the amount of that extra penetration was a little surprising. We were not prepared for bullets to penetrate an average of more than 6" deeper into the clear synthetic gelatin than the organic gelatin, in the heavy clothing test, for example.

The 10% organic gelatin used in our tests delivered predictable results, with bullets expanding and penetrating as they had in previous efforts from many sources. Shown is the 9mm Hornady Critical Duty 135+P. (Photo/Mike Wood)

IMPLICATIONS

With respect to the tested product, our results suggest the following implications:

- **The clear synthetic gelatin must be calibrated by the user before use**. The factory warranty cards cannot be relied upon to give an accurate measure of the product's calibration.

- **The clear synthetic gelatin currently demonstrates a tendency to limit bullet expansion and increase bullet penetration, compared to FBI-standard, 10% calibrated organic gelatin**. Based on our limited sample, this tendency seems to apply irrespective of bullet manufacturer, materials, design, construction, weight, pressure, or velocity. It seems that bullets penetrate significantly more in the clear synthetic, even when acceptable variations in organic gelatin penetration depth are accounted for.
- **The clear synthetic gelatin currently does not appear to be a suitable substitute for FBI-standard, 10% calibrated organic gelatin if the bullets will be measured and evaluated according to FBI performance standards.** Because the bullets we tested behaved so differently in the clear synthetic gelatin versus the 10% calibrated organic gelatin, it's not appropriate to use the FBI standards – which were designed to be applied to 10% calibrated organic gelatin – to measure bullet performance in the clear synthetic product.

  In example, it's inappropriate to measure and evaluate bullet penetration according to the FBI protocol (which rewards bullets that penetrate between 12" and 18" in 10% calibrated gelatin and penalizes those that fall outside this window) when bullets may routinely penetrate an extra 6" in the clear synthetic. If we did apply FBI standards to the clear synthetic, we might "pass" a bullet that normally fails the FBI protocol because it doesn't penetrate deeply enough. Conversely, we might "fail" a bullet because it over penetrates in the clear synthetic, even when it normally passes the FBI protocol because by remaining within FBI penetration limits.
- **There is no apparent "conversion" between data derived from 10% organic gelatin and the current version of the clear synthetic.** Unfortunately, our limited test doesn't indicate a conversion "shortcut" is likely. It would be convenient if we could develop a conversion factor that would equate the organic gelatin and clear synthetic gelatin, but our data indicate that bullet performance is too variable in these mediums to develop a universal "rule of thumb." Perhaps a skilled mathematician could derive a constant from a more complete sample, but we're not seeing one lurking in the data.

THE ROAD AHEAD

This test was a cooperative effort between multiple parties interested in obtaining useful data on the performance of the new synthetic gelatin compared to organic gelatin. Information was freely shared among the parties, including the manufacturer of the clear synthetic product.

It's important to note that the clear synthetic manufacturer was unhappy with how their product performed in our test, which has inspired them to take a close look at their product and quality control practices. As of press time, the manufacturer is engaged in an effort to modify the formula of the clear synthetic gelatin to enable it to pass FBI calibration. They are also taking steps to improve their quality control and inspection protocols to ensure that their products will comply with FBI standards for ballistic gelatin. When these changes are complete, a follow-on test will be conducted to evaluate the performance of the upgraded product, and the results will be published here.

For now, however, we're not comfortable with having law enforcement officers and agencies make ammunition decisions, using FBI protocol criteria, based on the results of testing in the current version of the clear synthetic gelatin. As a result of this project, there may be a time in the near future when an improved formula makes the clear synthetic a suitable substitute for FBI calibrated gelatin, but we're not currently there.

Enhancing the clear synthetic product would be an important advancement because we believe its advantages are numerous and compelling. If the formula for the clear synthetic could be altered to provide performance equivalent to that of 10% calibrated gelatin, it would be the runaway favorite for this kind of work. Legions of manufacturers, law enforcement agencies and individual hobbyists would cheer in unison to have a ready-made, temperature-stable clear gelatin that accurately replicated the troublesome organic gelatin. It would be a huge win for all of us to see that happen.

Until then, however, don't throw away your mixing buckets and molds.

About the author

Mike Wood is the son of a 30-year California Highway Patrolman and the author of "Newhall Shooting: A Tactical Analysis," the highly-acclaimed study of the 1970 California Highway Patrol gunfight in Newhall, California. Mike is an Honor Graduate of the United States Air Force Academy, a graduate of the US Army Airborne School, and a retired US Air Force Lieutenant Colonel with over 26 years of service. He's a National Rifle Association (NRA) Law Enforcement Division-certified firearms instructor, serves as a member of the PoliceOne Editorial Advisory Board, and has written the "Tactical Analysis" column at PoliceOne.com since 2014. Mike is the senior editor at RevolverGuy.com, and has been a featured guest on the Excellence In Training Academy and American Warrior Society podcasts, as well as several radio and television programs. He's grateful for the opportunity to serve and learn from the men and women of law enforcement.