The Los Angeles Silhouette Club

Is Your Bullet Weak Enough?

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With so many great moulds, casters, bullet makers, lubricants and great materials available, lead bullets have really come into their own. The art of shooting a lead bullet is such that every enthusiast can get great results from just a little bit of work. Now for the shooter who only looks to be putting holes in paper, this might not be for you, but you might pick something up as well.

Let's start by looking at the base material, lead. Lead is an interesting material, cheap, plentiful, and rather weak in it's base state. Compared to other elements in the periodic table as well as manufactured materials, lead just doesn't stack up, but works great for. Now of coarse the lead the can be strengthened by adding various other materials to the "pot" as well as heat treatment (heat treatment works by aligning molecules such that they aid each other in strength, like building blocks).

Material	Ultimate Compressive Strength (psi)	Ultimate Tension Strength (psi)
Cast Aluminum	9,000	15,000
Cast Brass	20,000	25,000
Rolled Copper	32,000	33,000
Cast Iron	80,000	20,000
Rolled Lead	7,000	3,200
Cast Tin	6,000	2,200
Cast Zinc	18,000	5,000

So you can see lead is pretty darn weak compared to other materials, but we use this to our advantage or detriment as long as we are mindful of it's limitations. This article is going to try to bring a little engineering knowledge to the art of bullet performance, so you, as the reader can really maximize performance of an old technology. The big bullet makers have got most of this down already so let's see if we can level the playing field some.

I assume that you already know the relationship between bullet hardness and barrel leading so it will not be covered here. Jim Taylor's article on leading is a great place to start if more information is needed as well as Lyman's Casting Manual. (Leading Defined)

Once we get the bullet out of the gun (internal ballistics), and down range (external ballistics) we now need to look at terminal ballistics (where the rubber "meats" the road). Terminal ballistics is what it's all about, making sure that what you shoot at goes down quickly and humanely, nothing is worse than seeing your game limping away to die a slow death. So let's see if I can help you pick the right material so when you have just perfect shot, it counts.

Let's start by relating velocity (a known quantity) and pressure (which is difficult to measure and quantify). In Duncan MacPherson's book, Bullet Penetration he has calculated and listed a table (Table 7-1) that relates Stagnation Pressure (defined below) with Velocity in water. Water has a very close relation to soft solid materials (like tissue and ordinance gelatin) that makes for a very good replacement, cheap and easy to get.

From the Fundamental of Fluid Mechanics the definition of stagnation pressure: "stagnation pressure is the largest pressure obtainable along a given streamline. It represents the conversion of all of the kinetic energy into a pressure rise.

Excerpts from Table 7-1

Velocity fps	Pressure psi	Velocity fps	Pressure psi	Velocity fps	Pressure psi	Brinell Hardness	Velocity fps	Pressure psi	Brinell Hardness
100	67	1900	24300	100	67	0.05	1800	21800	15
200	269	2000	26900	200	269	0.19	1900	24300	17
300	606	2100	29700	300	606	0.43	2000	26900	19
400	1080	2200	32600	400	1080	0.76	2100	29700	21
500	1680	2300	35600	500	1680	1.2	2200	32600	23
600	2430	2400	38800	600	2430	1.7	2300	35600	25
700	3300	2500	42100	700	3300	2	2400	38800	27
800	4310	2600	45500	800	4310	3	2500	42100	30
900	5460	2700	49100	900	5460	4	2600	45500	32
1000	6740	2800	52800	1000	6740	5	2700	49100	35
1100	8150	2900	56600	1100	8150	6	2800	52800	37
1200	9700	3000	60600	1200	9700	7	2900	56600	40
1300	11400	3100	64700	1300	11400	8	3000	60600	43
1400	13200	3200	69000	1400	13200	9	3100	64700	45
1500	15200	3300	73400	1500	15200	11	3200	69000	49
1600	17200	3400	77900	1600	17200	12	3300	73400	52
1700	19500	3500	82500	1700	19500	14	3400	77900	55

What this means for a bullet traveling through a fluid media (tissue) is the force (i.e. stagnation pressure) is greatest at the tip of the bullet or meplat which makes sense.

Pressure rises with the square of velocity, you could even deform cast iron if the velocity was greater than 3500 fps. Now let's add Brinell Hardness to the table. For a detailed explanation between pressure and Brinell Hardness grab Richard Lee's Modern Reloading 2nd edition.

Now let's add one more piece of information, Bullet Composition, I got this information from The Los Angeles Silhouette Club website at: (Cast Bullet Notes)

So your bullet has a great lube, and a gas check and leaves your bore spotless, but you can't understand why the terminal ballistics are so poor. Look at the table again, are you beyond the capabilities of your lead bullet, either to fast or to slow? Here's the same table in graphic form.

As you can see, the stagnation pressure and Brinell Hardness are closely related. This relationship is only for objects traveling in a fluid media, and does not take into account solids (i.e. bone). Please note that these velocities and pressures are only seen for a tenth of a millisecond (.0001 seconds) within a fluid before the bullet comes to a stop.

Velocity fps	Pressure psi	Brinell Hardness	Bullet Alloy
100	67	0.05	
200	269	0.19	
300	606	0.43	
400	1080	0.76	
500	1680	1.2	
600	2430	1.7	
700	3300	2	
800	4310	3	
900	5460	4	Lead
1000	6740	5	
1100	8150	6	
1200	9700	7	Tin
1300	11400	8	1 to 40 Tin Lead
1400	13200	9	1 to 30 Tin Lead
1500	15200	11	1 to 10 Tin Lead
1600	17200	12	WW (Clip On)
1700	19500	14	Lyman # 2
1800	21800	15	Linotype

Velocity fps	Pressure psi	Brinell Hardness	Bullet Alloy
1900	24300	17	
2000	26900	19	
2100	29700	21	
2200	32600	23	Monotype
2300	35600	25	
2400	38800	27	
2500	42100	30	Oven HT WW
2600	45500	32	
2700	49100	35	
2800	52800	37	
2900	56600	40	
3000	60600	43	
3100	64700	45	
3200	69000	49	Antimony
3300	73400	52	
3400	77900	55	Soft Commercial Brass
3500	82500	58	

So what sorts of scenarios can we relate to this data?

- Bullet punches straight through game, (you might want this if you have a large enough caliber and meplat).
- Velocity is low enough to keep the bullet's shape and travel in the intended direction.
- Bullet swerves off it's intended course missing the internal vitals but stays together.
- Velocity is just high enough to deform the nose of the bullet creating an asymmetric shape and unpredictable wound path.
- Bullet drives straight through the target creating a bigger hole on the exit side.
- Velocity is in harmony with the strength of the bullet, expansion was symmetrical allowing the bullet to travel in a straight line.
- Bullet comes completely apart and creates a shallow wound and misses all vitals.
- Velocity was far greater than the bullet strength and was unable to stay together.

So is your bullet weak enough to deform, or is it being pushed to hard to stay together? Are you expecting your cast hollow point to open up? Compare the hardness to the velocity you expect the bullet to be when it reaches the target (which is easy to do with online ballistics calculators). But at the end of the day, this is all analytical exercise, go out and test your bullet and see if it will perform the way you expect. Save those paper mil cartons, set up a row of them at the range and shoot them at the distance you plan on shooting your game.

Hopefully I've helped you take some of the mystery out of terminal ballistics and how to maximize your bullet's capabilities. Happy hunting, and go get dinner.

"Books I used for reference"

Modern Reloading 2^{nd} edition by Richard Lee
Engineering Formulas by Frank Sims
Fundamentals of Fluid Mechanics by Munson, Young & Okiishi
Bullet Penetration by Duncan MacPherson

(Mr. MacPherson's book is not the for the faint of heart, it's very similar to many of my college textbooks, but it is considered THE definitive work in modeling handgun bullets. Even John Linebaugh was a bit overwhelmed when he flipped through one of my copies).

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