Is Your Bullet Weak Enough?

With so many great moulds, casters, bullet makers, lubricates and great materials available, lead bullets have really come into their own. The art of shooting a lead bullet is such that every enuthasist 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 a 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 us. Now of course the Lead 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 Stength (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 its limitations. The 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 lets 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.

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's its 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 lets see if I can help you pick the right material when have just that one perfect shot, it counts.

Lets 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."

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.

Excerpts from Table 7-1

V-fps	Ps- psi	V-fps	Ps- psi
100	67	1900	24300
200	269	2000	26900
300	606	2100	29700
400	1080	2200	32600
500	1680	2300	35600
600	2430	2400	38800
700	3300	2500	42100
800	4310	2600	45500
900	5460	2700	49100
1000	6740	2800	52800
1100	8150	2900	56600
1200	9700	3000	60600
1300	11400	3100	64700
1400	13200	3200	69000
1500	15200	3300	73400
1600	17200	3400	77900
1700	19500	3500	82500

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

V-fps	Ps- psi	Brinell Hardness
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

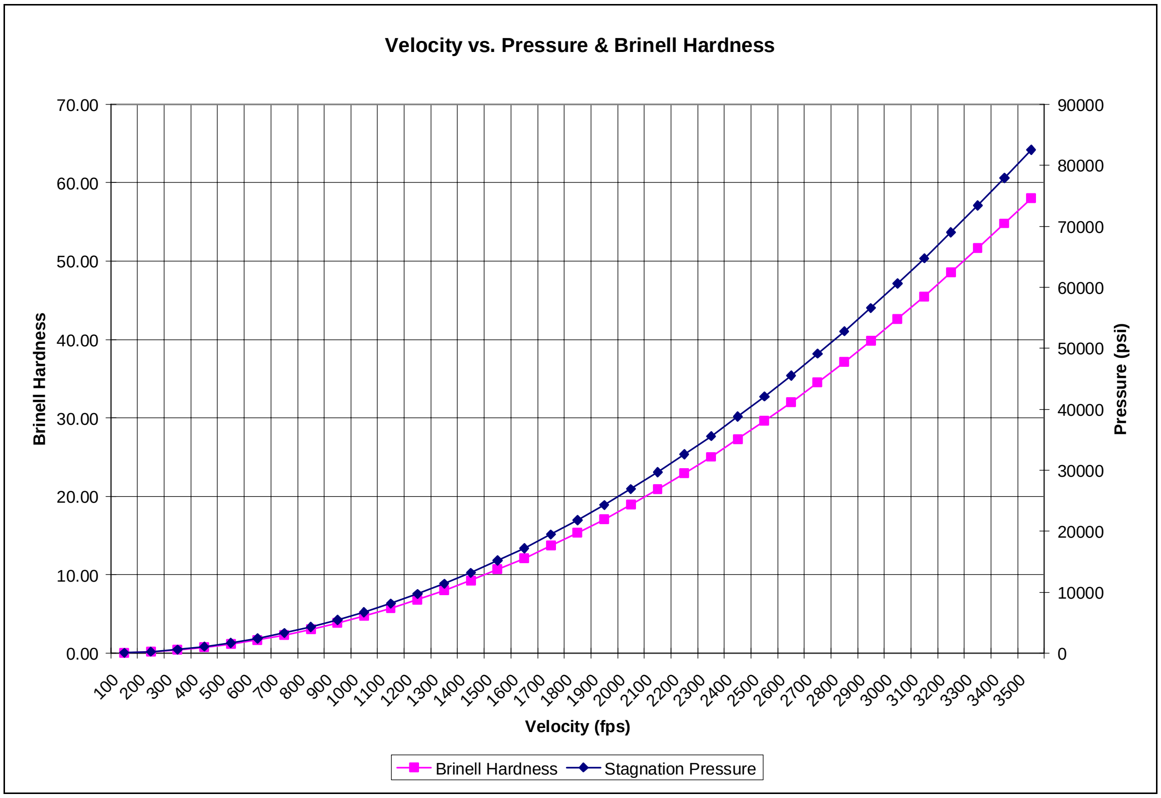
1000	6740	5
1100	8150	6
1200	9700	7
1300	11400	8
1400	13200	9
1500	15200	11
1600	17200	12
1700	19500	14
1800	21800	15
1900	24300	17
2000	26900	19
2100	29700	21
2200	32600	23
2300	35600	25
2400	38800	27
2500	42100	30
2600	45500	32
2700	49100	35
2800	52800	37
2900	56600	40
3000	60600	43
3100	64700	45
3200	69000	49
3300	73400	52
3400	77900	55
3500	82500	58

Now lets add one more piece of information, Bullet Composition, I got this information from The Los Angeles Silhouette Club website (http://www.lasc.us/CastBulletNotes.htm).

V-fps	Ps- 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	
1000	6740	5	Lead
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	
1800	21800	15	Lyman # 2
1900	24300	17	
2000	26900	19	LinoType
2100	29700	21	
2200	32600	23	
2300	35600	25	MonoType
2400	38800	27	
2500	42100	30	Oven Heat Treated 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 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 too slow?   Here's the same table in graphic form.



As you can see, the stagnation pressure and Brinell Hardness are closely related. And 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 mllisecond (.0001 seconds) within a fluid before the bullet comes to a stop.

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

- Bullet punches straight though game, (you might want this if you have a large enough caliber)
  - Velocity is low enough to keep the bullet's shape and travel in the intended direction.
- Bullet swerves off it's intended course missing 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 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, this is all analytical exercise, go out and test your bullet and see if it will perform the way you expect. Save those paper milk cartons, set a row of them up 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 2nd Edition by Richard Lee
Engineering Formulas by Frank Sims
Fundamentals of Fluid Mechanics by Munson, Young & Okiishi
Bullet Penetration by Duncan MacPherson copies can be found at
http://www.firearmstactical.com/bulletpenetration.htm
(Mr. MacPherson's book is not for the faint of heart, it's very similar to many of my college textbooks, but 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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