Dixie  *Slugs*

Force Factor

Bullets and Game: What Really Happens

If there is anything I have learned over the past fifty years of big game hunting, it is that there are no two killing wounds on animals that are the same. There are just too many variables including, angle of bullet's path through the animal, mental condition of the animal, age of the animal, and the bullet itself (weight, velocity, sectional density, and construction.). There are two basic schools of thought on the desired results the shooter wants from his bullet. One is Energy Deposit and the other is Momentum. Modern jacketed bullet manufacturers attempt to combine the two, with varying success. Let's explore this in general.

Energy Deposit: The theory is that a projectile by having weight and velocity, the Kinetic Energy formula applies. This formula was developed in steam engine days to relate the power of the engine's work ability (piston size/steam pressure) to lift weight a prescribed height against gravity. It will be up to you, my readers, to decide the validity of this formula to the terminal performance a bullet. The adherents to this believe that as a jacketed bullet penetrates (and expands) and decelerates in tissue, it transfers Kinetic Energy (in foot pounds) to the animal. This transfer causes first a Primary Cavity and then a Secondary Cavity, which called by many the Permanent Wound Channel (PWC). Since water in the animal's tissue (up to 90% by weight) cannot be compressed, therefore it is violently displaced causing the Primary Cavity. It is thought that as this Primary Cavity expands, in milli-seconds, it causes a hydrostatic energy wave to move through all adjoining tissue. This hydrostatic energy wave is supposed to cause a paralyzing Nerve Shock and cause a disruption of the faculties. This, for the lack of a better way, is used to describe the Hydrostatic Energy involved and this is the way Paper Ballistics on bullets are described today.

Momentum: The adherents of this theory push the belief that a non-expanding bullet must penetrate very deeply, causing a Permanent Wound Channel (PWC), and destroy critical nerve centers, the brain, and vital organs that an expanding bullet is unable to reach. This theory has merit, as no matter what the mass of the animal is, if its brain or spine is destroyed it's all over. The African hunter of big game prescribes to this school of thought. The PWC destroys tissue, thereby causing hemorrhage. The combined area of this PWC is directly related to Bleed Down, which deprives the animal's brain of oxygen. The shape of the nose, and its construction, is most important for deep penetration. To keep the bullet from deviating form its path, a round nose is suggested as best.

Pressure Vs Energy: Although many shooters think they are the same, they are not.

Physics Definition – "**Pressure** is force applied over a surface area, measured as force per unit of area."

Physics Definition - Kinetic Energy: "That a physical system is capable of doing in changing from its actual state to a specified reference state. The total including , in general, contributions of potential energy, kinetic energy, and rest energy".

Another Important Discovery: Veral Smith, while testing various bullet shapes, stumbled onto one of the most important facts concerning bullet meplats. Using the Keith #429421 SWC bullet, he painted the meplat and front driving band with marker pen. The bullets were then fired into water and recovered. To his amazement, the paint was gone on the meplat, but was still on the driving band. He continued his experiments and proved beyond a shadow of a doubt that fluid was driven away from the meplat along its plane! This, of course, led him to the development of his LBT bullet design. I feel this was the most important discovery concerning hard cast bullets since 1925! With this in mind, you will better understand the following text.

Which Theory Is Correct, KE or Momentum? After spending hours attempting to relate the ballistic formulas with my actual experience in observing game reactions after bullet impact and tissue destruction, I have decided that the closest formula relating to terminal performance is a modification of "Taylor's Knockout". In the formula for Kinetic Energy, it is described in Foot Pounds (the amount of force to lift one pound one foot) and the Velocity is squared. I do not believe this squaring of the velocity gives a true picture in ballistics! Taylor's formula: Weight of the bullet (in grains / 7000 grs. per pound) X Velocity (in feet per second) X Caliber (diameter in inches) = Taylor's Factor. He originally designed this formula to compare the killing power of roundnose full- jacketed bullets on African game. It is still a good formula for that, however it needs modification to cover both non-expanding hard cast and expanding jacketed bullets. Let us first understand that the Meplat Area (MA) of a bullet can be described as the frontal area of a cast non-expanding bullet, but also as the frontal area of an expanded jacketed bullet as well. Force (pressure) is moved from the Area of the Meplat (MA) to living tissue. As the MA increases, the Force (pressure) that is transferred to tissue is also increased. We do find from tests that penetration is inversely proportional to expansion. When bullets expand, they usually penetrate measurably less than another bullet of the same weight, which does not mushroom even though striking the same medium at the same impact velocity. Now, the definition of this Force (pressure) is up to your interpretation, whether it is Hydrostatic Shock, Hydraulic Pressure, Energy Transfer, or whatever! I will not go further into that subject except to say that the more Force (pressure) that is applied to the water in tissue, the more damage occurs. However, tests (and experience) generally favor heavier, 185 to 265 gr. big bore (.35" to .45" caliber) bullets whether they expand or not, if sufficient velocity can be had within the strength of the firearm. In general terms, we must also understand that bullet performance is dynamic and the dwell time in living tissue greatly affects the destruction of that tissue. Many feel that the Primary Cavity formed in tissue shortly after bullet impact has little effect on terminal properties and is generally associated with expanding bullets. Whether it does or not, is not important, but rather what causes it! Water in animal tissue, being non compressible (therefore is a solid), is moved by the Force (pressure) related velocity and the Area of the Meplat (expanded or not) of the bullet. It is this violent movement of water (as a solid) in the tissue that causes tissue damage! In order to take into consideration the Area of the Meplat (MA) we must modify Taylor's original formula to. **(Weight of the Bullet in grs. divided by 7000 grs. per pound) X Velocity (ft. per. sec.) X MA(3.1416 X diameter of the meplat squared) divided by 4 = Force Factor**. The "MA" part of the formula is the area calculation for the frontal area of the meplat.

Now let's see examples of known bullets

(1) .44 Mag. - BTB .432" 265 gr WFN GC / meplat .340"(1200 fps-1400 fps-chrono)
.0379 X 1200 fps X .0908 sq. in. = 4.1296 Force Factor - (Handgun)
.0379 X 1400 fps X .0908 sq. in. = 4.8178 Force Factor - (Handgun)
(2) .44 Mag. - Rock Island .431" 265 gr TCW GC / meplat .325" (1835 fps chrono)
.0379 X 1835 fps X .0830 sq. in. = 5.7724 Force Factor (Marlin 1894P)
(3) .357 Mag - BTB .358" 185 gr FN GC / meplat .280" (at 1400 fps and 1700 fps)
.0264 X 1400 fps X .0616 sq. in. = 2.2787 Force Factor- (Handgun)
.0264 X 1700 fps X .0616 sq. in. = 2.7646 Force Factor- (Rifle)
(4) .44 Mag - Keith #429421 .432" 250 gr SWC PB / meplat .280" (at 1200 fps).
.0357 X 1200 fps X .0616 sq. in. =2.6389 Force Factor- (Handgun)
(5) .44 Mag - BTB .432 240 gr WFN PB / meplat .340" (at 1200 fps)
.0343 X 1200 fps X .0908 sq. in. = 3.7373 Force Factor- (Handgun)
(6) .444 Marlin - BTB .432" 355 gr WLN GC / meplat .340" (at 2154 fps)
.0507 X 2154 fps X .0908 sq. in. = 9.9161 Force Factor- (Rifle)
(7) .444 Marlin - BTB .432" 405 gr WLN GC / meplat .340" (at 1837 fps)
.0579 X 1837 fps X .0908 sq. in. = 9.6577 Force Factor- (Rifle)
(8) .30-06 Springfield - Nosler .308" BT / various expanded meplat (at 2600 fps)
.0247 X 2600 fps X .0962 sq. in. (.350" expansion) = 6.1787 Force Factor
.0247 X 2600 fps X .1257 sq. in. (.400" expansion) = 8.3993 Force Factor
.0247 X 2600 fps X .1590 sq. in. (.450" expansion) = 10.6273 Force Factor
.0247 X 2600 fps X .1963 sq. in. (.500" expansion) = 13.1168 Force Factor

I don't really know which of these expanded meplats would apply for the Nosler 180 BT @ 2600 fps, however, it is interesting to see the change in the Force Factor as the expansion of the meplat (MA) is increased. Therein is the problem of expanding bullets, what might be perfect expansion in handgun bullets at ten yards, may fail to expand at all out at seventy five yards! It is most important to remember that MA decreases in expanding bullets as velocity decreases, where there is no change in MA of a hard cast bullet as velocity decreases!

Note how important the meplat area (expanded and non-expanded) is to the final outcome of the calculations. Also, note the increase in Force Factor in the .30-06 as the expansion (meplat area) is increased.

So, what have we done? We have taken an accepted formula, designed by Taylor to compare bullets, and logically modified it by the substitution of bullet diameter with the Area of the Meplat. It shows again, what we have learned in the game fields and ballistic labs, that the meplat area is very important, whether expanded or not! Remember here, Veral Smith's discovery of what happens on the meplat.

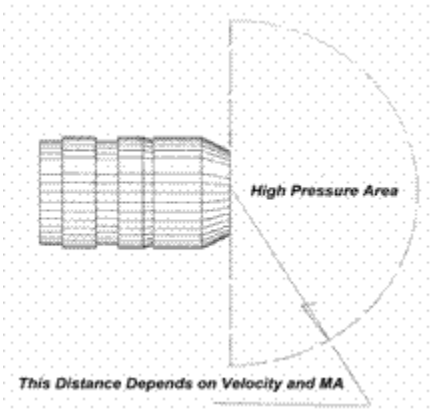
In living tissue, there is another consideration that is often overlooked. In some game animals the tissue is much dryer and tends to be more elastic. In this dryer tissue the percentage of water to volume of tissue is lower. The less water means less temporary cavity and MA becomes even more important is tissue destruction. An example close to home is the comparison of the tissue in a wild hog verses a Whitetail deer. This, with the fact that the wild hog does not have as high profile nervous system as a deer, calls for

more tissue damage. It's a proven fact that the wild hog can absorb more terminal damage. These facts must be taken into consideration in the selection of caliber /weight of bullet/velocity and that selection should be based on the animal. There is one interesting side light of the Force Factor that may, or my not, be applicable. Notice if one multiplies the Force Factor by 100 how it relates to what is accepted as caliber/weight/velocity to the weight of animal hunted. Some thought is in order on Sectional Density (Weight of bullet in grains) divided by 7000 divided by the diameter of bullet squared). Other words, it is a formula you calculate the amount of weight that is applied to the face of the bullet. The more weight applied, the area on the face and velocity being constant, the deeper the bullet will penetrate in flesh/muscle/water. In a non-expanding bullet this penetration will be deeper than an expanding bullet. To understand the dynamics of this, one must understand that as the bullet expands, it offers more surface area to resistance. In non- expanding bullets there is a point of diminishing returns. As weight goes up, velocity must fall, within known pressure parameters. Here again, the meplat of the bullet comes into play. The larger the Meplat Area, the more resistance. So we find ourselves back where we began, examining the Force Factor. It appears that somewhere around .375" bullets, that non-expanding bullet types run the factor up. When we reach this meplat area, velocity and weight come into play. Above .375" bullets, there seems to be little gained in expanding bullets, if the velocity remains the same. If the bullet has a large meplat (either hard cast or expanded jacketed type) the PWC and penetration will be high! This is seen in the increase also in the Force Factor. It appears, from all actual tests, that the ideal nose shape for non-expanding bullets is a modified truncated cone, having a very large meplat. This moves the center of gravity near the center of the bullet longitudinally and shortens the bullet. This adds to the bullet's stability in flight. There will be a loss in Ballistic Coefficient, but there will be little change in trajectory within reasonable ranges.

So, have we defined killing power, not really! There are just too many variables to do that. What we have done it set up a method of comparing the Force generated by one bullet to another. If we were to recover a bullet from a cartridge that was accepted for a certain weight animal we could compare the Force Factor generated by another bullet (knowing the impact velocity, weight, and Area of the Meplat (expanded or not) of the recovered bullet. To simplify your calculations, the following table shows the Meplat Area in square inches where the d (diameter of the meplat) is known.

d	sq. in.	d	sq. in.	d	sq. in.	d	sq. in.	d	sq. in.
.250"	.0491	.300"	.0707	.350"	.0962	.400"	.1257	.450"	.1590
.255"	.0511	.305"	.0731	.355"	.0990	.405"	.1288	.500"	.1963
.260"	.0531	.310"	.0755	.360"	.1018	.410"	.1328	.600"	.2827
.265"	.0552	.315"	.0779	.365"	.1046	.415"	.1353	.700"	.3849
.270"	.0573	.320"	.0804	.370"	.1075	.420"	.1385	.800"	.5027
.275"	.0594	.325"	.0830	.375"	.1104	.425"	.1419		
.280"	.0616	.330"	.0855	.380"	.1134	.430"	.1452		
.285"	.0638	.335"	.0881	.385"	.1164	.435"	.1486		
.290"	.0661	.340"	.0908	.390"	.1195	.440"	.1521		
.295"	.0683	.345"	.0935	.395"	.1225	.445"	.1555		

For meplats (d) not listed here - Pi (3.1415) X d (meplat") X d (meplat") divided by 4



Physics: The angle of Deflection equals the angle of Inflection

Here we see a diagram showing the high-pressure area, however it is not to scale. This high-pressure area is where the most tissue damage occurs. Note that the pressure area leaves the meplat 90 degrees to the path of the bullet. The radius shown, based on the Velocity and Meplat Area (MA) is what causes the Permanent Wound Channel (PWC). It has been found by using high-speed photography that there is a relationship in the shape of the Permanent Wound Channel (although smaller) and the Temporary cavity. It is generally accepted that this Temporary Cavity aids in the terminal performance of a bullet, but to what extent is not known.

Foot Pounds of Energy per Square Inch of Meplat Area

Even if you do not accept the validity of the Force Factor formula and still cling to the old KE calculations, you must accept the fact that the area of the meplat (expanded or not) must be taken into consideration. One can take the MA (meplat area) and multiply in times the KE (foot pounds of energy) and get the pounds per square inch of meplat. This, in itself, has some interesting insight in comparing one bullet's performance against another.

(Weight of bullet in grs) X velocity X velocity divided by 450,240 X MA (meplat area)

Final Force Factor Calculation-Dixie Slugs Xterminator

For the last example: Let’s take the Dixie Slugs Xterminator and work it through. We have a .730” bullet/slug weighing 730 grs with a velocity of 1400’/”.

.1043 X 1400 X .4185 equals a Factor of 61.11. Obviously a powerful load for heavy and/or dangerous game in dense cover! Dixie Slugs is re-introducing, and exceeding, the famous large bore Paradox loads in 12 bore and 20 bore for modern shotguns with rifled barrels and rifles chambered for 12 and 20 bore.

We have discussed (and maybe cussed) the importance of understanding the dynamics involved with terminal performance of bullets in living tissue. I hope this write-up has shed some new light on the importance of selecting a proper bullet shape, especially the meplat. We are just beginning to understand what really happens, and why it happens, when the various bullet designs are used. Testing will go on, revised designs will be born, and bullet efficiency will be increased. That's the nature of things!