2008 Study Update, Part 5

By

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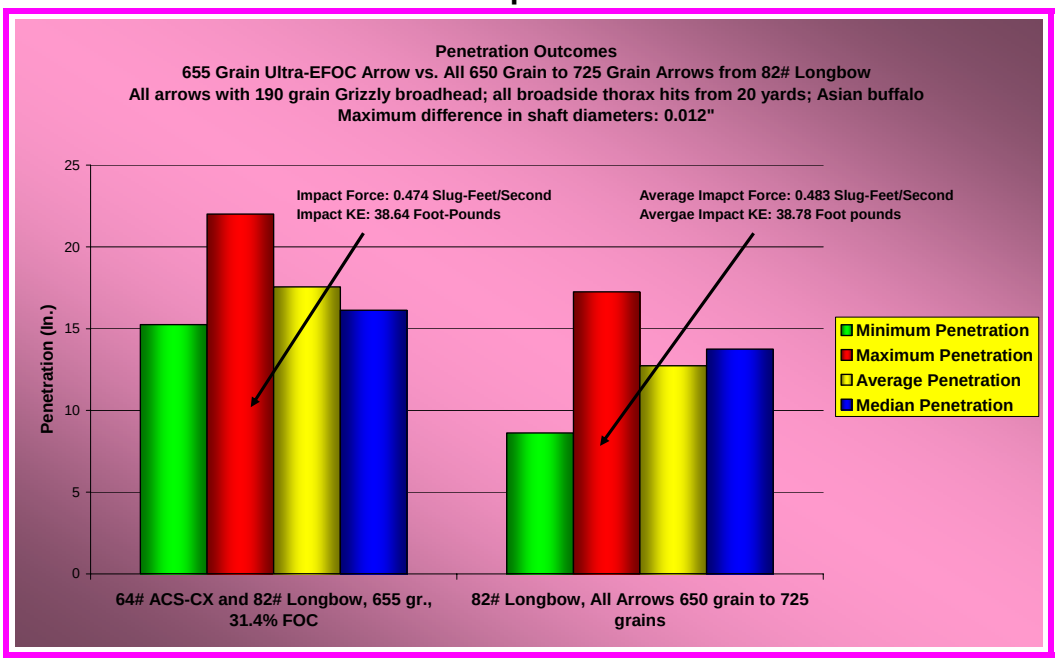
The 2008, Part 4 Update examined the test results for a penetration-enhanced, slightly above threshold mass, 655 grain Ultra-EFOC arrow from both the 82# and 64# ACS-CX longbows. It compared those results against slightly below-threshold High and EFOC arrows from the same bow. In Part 5 we'll look at some of the most interesting and meaningful comparisons to come from the Study; comparing the performance of these barely above threshold mass Ultra-EFOC arrow's to that of other arrow groups from the 82# longbow, including the classic super heavy "buffalo arrows" having normal, high and Extreme FOC arrows. **[It is important to remember that all arrow setups used in all test sequences were bare shaft tuned to show straight, true and stable arrow flight at all ranges from 3 meters to 40 meters; the maximum distance at which bare shaft flight was tested.]**

Ultra-EFOC vs. Higher-Mass Lower-FOC

Graph 19



Graph 19 shows a comparison between all thorax hits with the 655 grain Ultra-EFOC arrow and the average results of all comparable shots for Normal, High and Extreme FOC arrows with a mass-weight between 650 and 725 grains, all from the 82#

longbow. The "comparable shots" include those: (1) having the same broadhead (the 190 grain Grizzly) (2) retaining structural integrity; (3) fired from same shooting angle and shot distance; and (4) having thorax impact.

There is a difference in size of the test animals included in each group. The Ultra-EFOC arrow was tested exclusively on "massive bodied" Asian buffalo bulls; the largest 'body-size category'. Test animals in the 'all arrows' group included everything from "adult cows" to the "trophy" and "massive" bull categories. This difference gives an advantage to the 'all arrows' group, which, as we'll soon see, makes the results even more impressive.

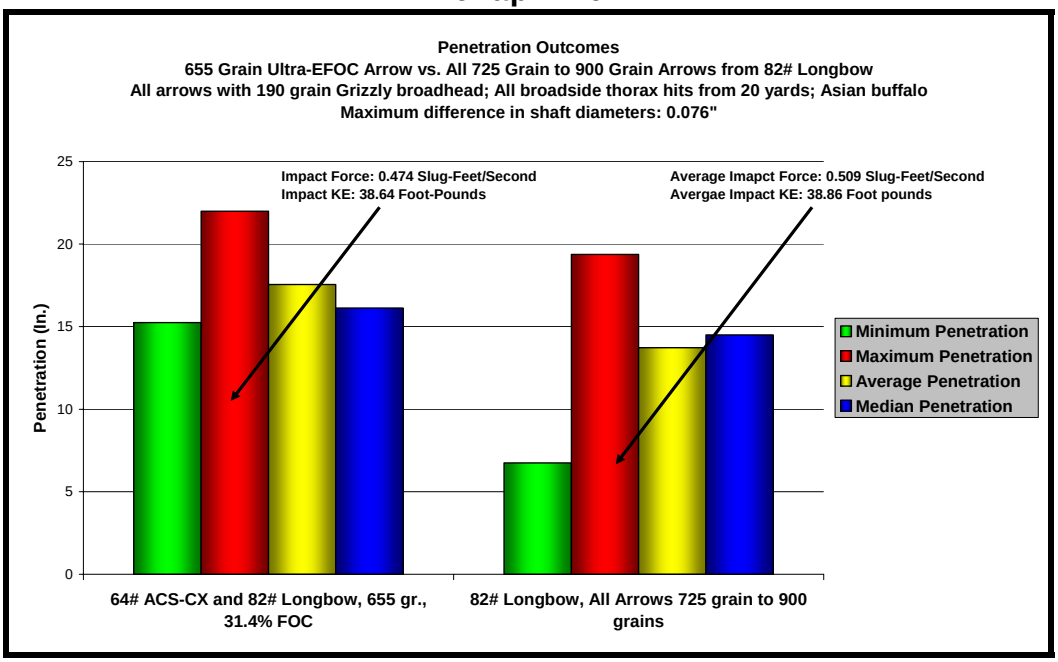
As you might recall from the 2008, Part 3 Update there is a significant difference in 'impact-zone' rib thickness between even a young adult Asian buffalo bull and that of a fully mature bull. For a young adult bull the rib thickness ranges from 7.15mm (0.281") to 8.1mm (0.319"), depending on the specific location of the bone-thickness measurement. At corresponding locations the rib thickness for buffalo cows; even mature adults; is slightly less. The aggregate difference in average rib thickness between a young adult bull and a mature bull is approximately 18%; or roughly 0.10".

The maximum difference in shaft diameters among all arrows in Graph 19's two arrow grouping is only 0.012". This is because none of the 82# bow's hardwood-shafted arrows fell within this weight group. All setups in this 'all arrows' group have synthetic shafting.

The 'all arrows' group contains no arrow having a mass-weight below threshold-value. They show a 100% rate of breaching the entrance-side ribs. Most important to note is the 'all arrows' maximum penetration value. With the numerous different types of arrows, weights and FOC's in the 'all arrows' group, a few 'bad performing' shots might lower the overall average penetration, but they would not affect the maximum penetration shown. **No arrow in the 'all arrows' group achieved the degree of penetration demonstrated by the lower-mass Ultra-EFOC arrow. Indeed, the maximum penetration shown by any arrow in the 'all arrows' group is slightly less than the *average* penetration shown by the Ultra-EFOC group.**

Despite the lower mass and increased test animal size the Ultra-EFOC arrows shows a decided advantage in penetration. Their average penetration shows an increase of 37.9% over that of the 'all arrows' group. Now let's up the arrow mass a bit and make this comparison again.

Graph 20



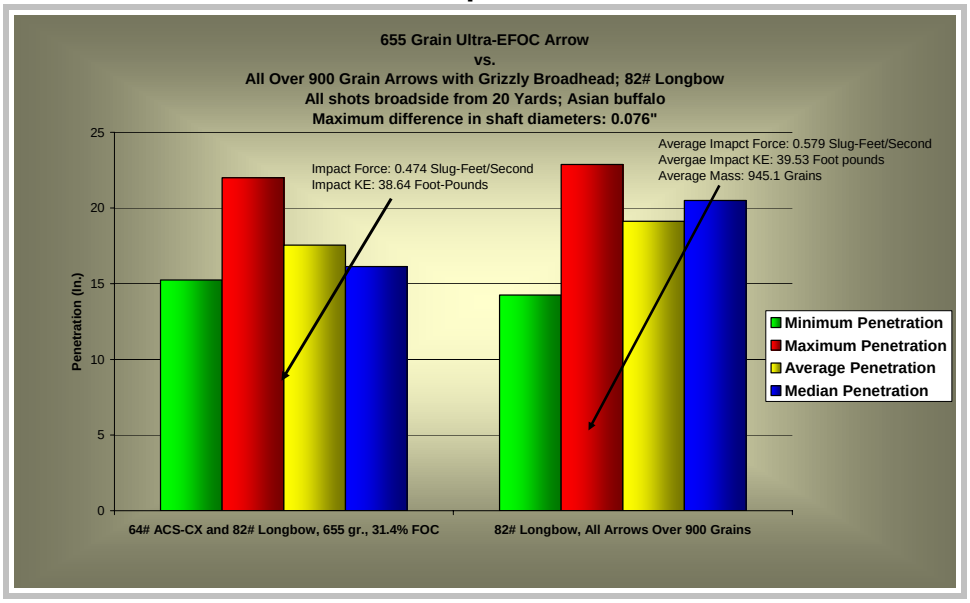
In Graph 20 we've increased the arrow-mass range for the comparison set to include all arrows from the 82# bow that have a mass-weight between 725 and 900 grains. Again we're looking only at the structurally intact arrows, having the 190 grain Grizzly broadhead, shot broadside from 20 yards and striking directly into the thorax. We've again included all size test animals in the 'all arrows' group; "adult cows" to "massive bodied" bulls.

The 725 to 900 grain group again includes all Normal, High and Extreme FOC arrows meeting the shot criteria. There's now a greater variance in shaft diameters, with the maximum difference being 0.076", but don't be mislead by this. Even the largest diameter shaft still shows a favorable ferrule diameter/shaft diameter ratio of 5.75%. Once again, the bone-breaching rate for all arrows, in both groups, is 100%.

In this comparison the Ultra-EFOC arrow is giving up from 70 to 245 grains of arrow mass to the 'all arrows' group. The difference in arrow mass and test animal size notwithstanding, **the Ultra-EFOC arrows averaged 27.8% more penetration than the 'all arrows' group.**

So far the Ultra-EFOC arrow is more than holding its own against the 82# bow's heavier arrows, but how will it stack up against the classic buffalo arrows; the super-heavy arrows? Let's take a look and see.

Graph 21



Here we have the 82# bow's super-heavy, 900-plus grain arrows having the same broadhead; the 190 grain Grizzly. As with the above comparisons the heavier arrow group includes all thorax impact, 20 yard broadside shots for structurally intact arrows. It includes both male and female buffalo. The arrows in both groups show a 100% rate for breaching the entrance-side ribs.

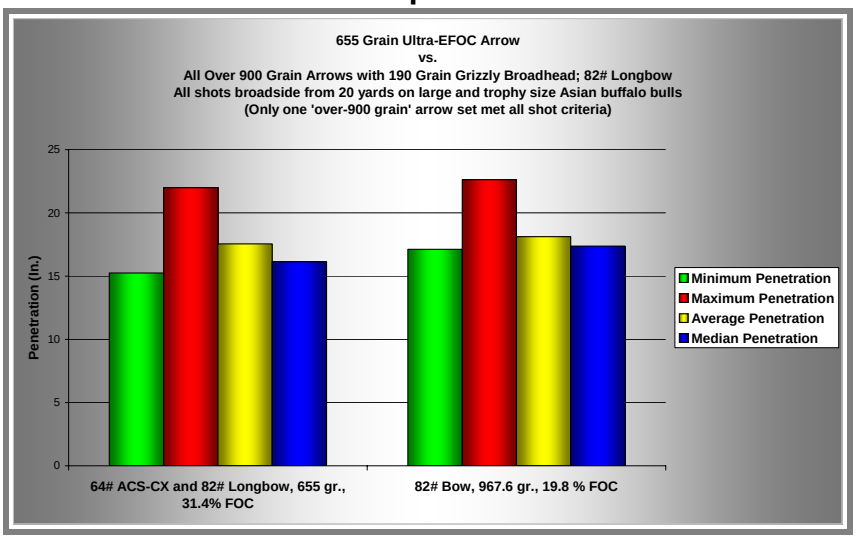
Average mass of the super-heavy arrows shown in Graph 21 is 945.1 grains. These super-heavy arrows represent a mixture of heavy wood shafts, such as ipe, and double shafts consisting of one synthetic shaft within another, but the bulk have either Safari or Big Five GrizzlyStiks shafts. The GrizzlyStiks are tapered, giving the shaft a weight-forward design. Additionally, many of the double shafts are either forward weighted (weight added back of the insert) or partially double-shafted, also creating a weight-forward situation. Because of this, fully 80% of the super-heavy arrows shown have a FOC between 19% and 20%, placing them into the EFOC range.

While the minimum and maximum penetrations are virtually identical the Grizzly tipped, super-heavy group shows an increase in average penetration of 8.2%. More significantly their median penetration shows an increase of 26.2%. This is with a 22.2% increase in average impact force (momentum).

Among all the arrows from the 82# longbow having the same broadhead it is in this comparison that the 655 grain Ultra-EFOC first meets an *apparent* penetration match … *but there is the marked difference in size of the test animals to be considered*.

In this 'above-threshold Ultra-EFOC vs. classic buffalo arrows' comparison the Ultra-EFOC arrow is giving up from 245 to 460 grains of mass-weight advantage to the super-heavy arrows yet, despite the lower mass and the larger size of the test animals, the Ultra-EFOC arrow shows a greater 'minimum penetration' and only 4% lower 'maximum penetration. How would the performance of the welterweight Ultra-EFOC arrow compare if we leveled the playing field by comparing only the 82# bow's super-heavy, 190 grain Grizzly tipped arrows that were tested on comparably large, "massive bodied" bulls?

Graph 22



Graph 22 segregates the 190 grain Grizzly tipped 'over-900 grain' arrow group to include only those shots taken on "massive bodied" bulls; animals of comparable size to those the Ultra-EFOC arrow was tested on. While the preponderance of over-900 grain arrow sets were tested on "mature" or "trophy" bulls only one particular arrow set; the EFOC (19.8%) GrizzlyStiks Big Five shaft with the 190 grain Grizzly broadhead; was tested on a comparable size, "massive bodied" bull.

Comparing only the shots on animals of like body size the penetration of the 312 gain lighter, 31.4% Ultra-EFOC arrow is near identical to that shown by the substantially heavier, 19.8% EFOC arrow. Average penetration between the two arrow sets now differs by only 4.6%; and median penetration by 7.2%. **Tipped with identical broadheads, this puts the terminal performance of this 655 grain, 31.4% Ultra-EFOC arrow very near that of a 'classic', super-heavy "buffalo arrow" having 19.8% EFOC; an outcome nothing less than phenomenal!**

Before some proponent of arrow velocity and kinetic energy jumps up to say arrow FOC had nothing to do with it; that it was the lighter arrow's higher velocity which made the difference in penetration, it should be pointed out that the difference in impact velocity between these two arrows is only 31 feet per second, and the difference in impact KE is a mere 1.04 foot-pounds! And I can already see the cogs turning again; "Ah! Near equal KE and near equal penetration, that's the answer!" Here I must refer you back to Graph 14, in Part 3 of the current Updates. With near identical profile arrows having equal mass, a 65.3% difference in impact KE made virtually no difference in outcome penetration.

Need more convincing? Reread all of Parts 2 and 3 of the current Update series. Note each of the penetration comparisons between the EFOC and Ultra-EFOC arrows from the 40# recurve and the 'comparable shot/same broadhead' groups from the 70# and 82# bows. *Every arrow* from the 40# recurve is traveling slower and carrying less Kinetic Energy than ***any*** arrow in the heavier-bow groups yet, overall, their performance equals or exceeds that of the faster, higher impact KE arrows.

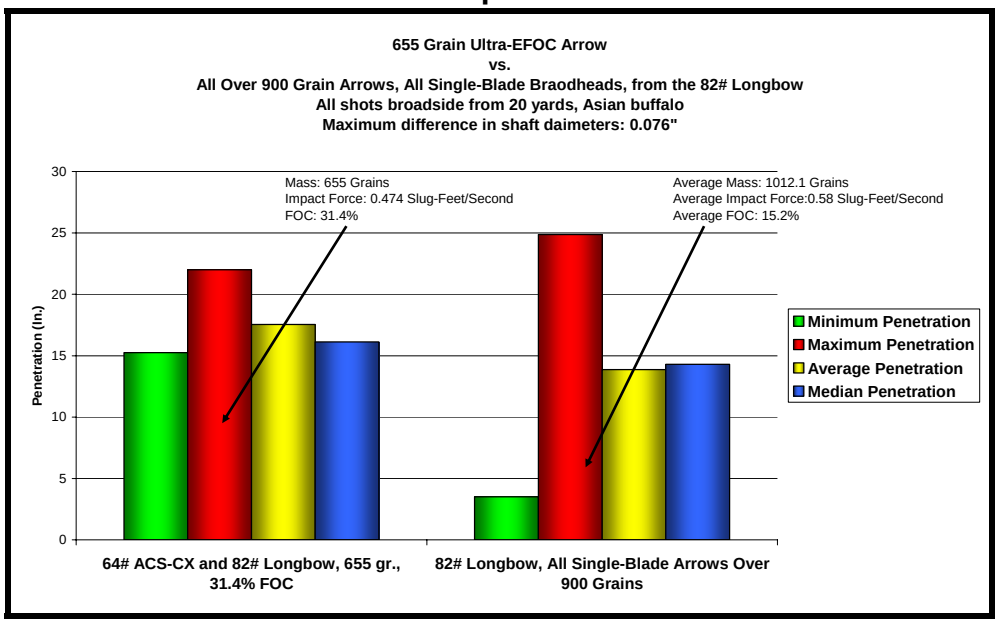
Want to speculate on the difference in average impact KE between arrows from the 40# bow and those from the heavier bows? The 'same broadhead' arrow groups from the heavier bows carries from a *minimum* of 46.4% greater impact Kinetic Energy to a maximum of 69.5% more. **It is impossible to equate the demonstrated penetration outcomes to either the arrow's velocity or its Kinetic Energy. Not even the vaguest of correlations is indicated.** Indeed, when we compare bone-breaching shots for the 40# bow's Ultra-EFOC arrow against the 'all arrows, same broadhead' group (Graph 7) from either the 70# or 82# bows there is an inverse correlation; the higher velocity, higher KE arrows show *lower* average penetration!

Clearly, *for structurally secure arrows having perfect flight and above-threshold mass*, arrow design factors are the preeminent determining factors of arrow penetration, showing a greater degree of effect than either Kinetic Energy or impact force (momentum). However, it is important to recognize that when arrow design factors and arrow flight ARE EQUAL it is change in the arrow's momentum which correlates, percentage wise, with the change in penetration; and that arrow momentum derived from arrow mass contributes more, percentage wise, to outcome penetration than does momentum derived from increased arrow velocity.

Before moving on, take a moment to consider the setup of Graph 22's over-900 grain arrow. This is a tapered GrizzlyStiks shaft with brass insert, a 125 grain steel broadhead adaptor and the 190 grain Grizzly broadhead. Developing a well tuned Ultra-EFOC arrow requires considerable time and effort; something not everyone enjoys. For those looking for a highly effective, easy to tune, virtually off the shelf EFOC heavy-game arrow this is about as ready made as they come.

The above comparison(s) of the slightly above threshold Ultra-EFOC arrow against classic buffalo arrows having the same broadhead begs for a similar comparison against 'all single-blades' for the 82# bow's super-heavy arrows.

Graph 23



The '900-plus' group in Graph 23 includes *all single-blade broadheads*, not just the 190 grain Grizzly. Only shots retaining structural integrity are included. Some of the broadheads, such as the Ribtek Big Game Pro and Outback Supreme, have a mechanical advantage (MA) as high as that of the 190 Grizzly. Others, such as the Modified Grizzly and Grizzly Extreme, have a higher MA than the 190 Grizzly. This group's remaining broadheads consist of other single-blades often used on heavier game; the Silver-Flame, standard Ribtek, Cheetah, Zwickey Eskimo, Magnus II, Ace Standard, Bear Razorhead (sans bleeder blade), Blackstump, etcetera.

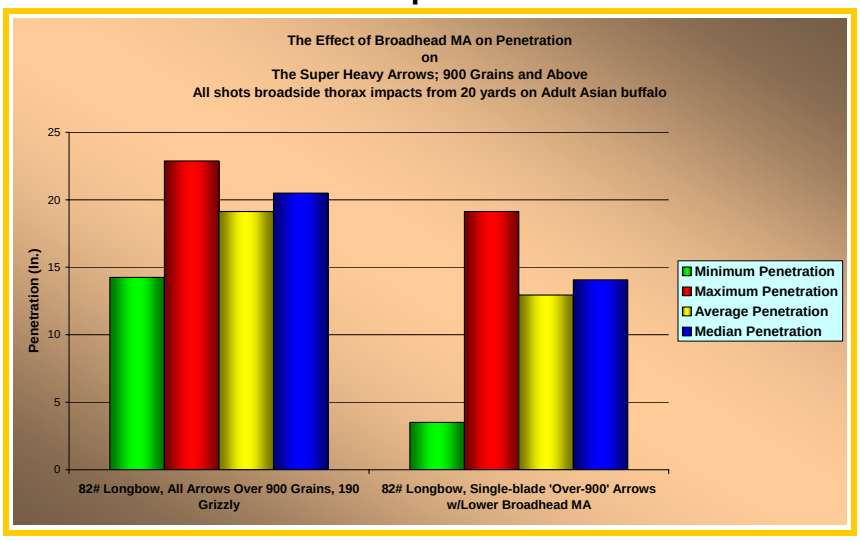
Not represented are wide-cut, relative low MA single-blade heads such as the Zwickey Delta or Magnus I. They are rarely used on heavy game arrows, and for good reasons; note the

minimum penetration (green bar) for the 'all arrows' group. Even when restricted to just the (relatively) higher MA single-blade broadheads a few of these super-heavy arrows still failed to penetrate the entrance rib. For these 'structurally intact super-heavy arrows' each failure to penetrate the entrance rib(s) occurred with broadheads lacking a smooth profile; either open-ring ferrules, protruding ferrule attaching lugs or poor ferrule fade-in to the blade.

When all single-blade super-heavy arrows are considered the outcome is reversed from what was shown in Graph 21. **Though the average mass of arrows in the 'all single-blades' group is 1012 grains and they average 22.4% more impact force, both average and median penetration of the 655 grain, Ultra-EFOC arrows is greater; by 29.5% and 13.2%, respectively.**

The two different groupings of 900-plus grain arrows shown in Graphs 21 and 23 have another message that should not be overlooked. They make a very pointed statement about the influence on terminal performance your choice of broadhead has. This message becomes even more incisive when you consider that 27.1% of the broadheads in Graph 23's 'all single-blade' group have MA equal to or exceeding that of the 190 grain Grizzly. As the following graph (Graph 24) shows, the influence of broadhead design on terminal performance is hard to overstate.

Graph 24



On the left side of Graph 24 is the 'Over-900' arrow group from Graph 21: "all super-heavy arrows having only the high MA, single-bevel, 190 grain Grizzly". On the right are all Over-900 grain arrows *having single blades with a MA lower than that of*

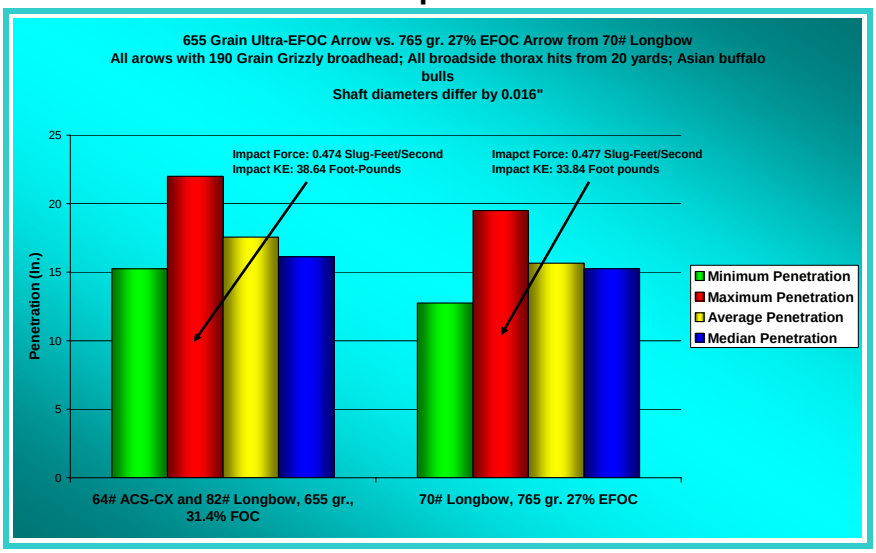
the 190 grain Grizzly. A look back at the text under Graph 23 will give you an idea of the specific class of single-blade broadheads included. When compared to a full cross-section of broadheads available each broadhead included in this 'other single blade' group would have at least a moderately high MA.

What this analysis shows is a difference in 'likely outcome' penetration of 37.9% to 43.3%, depending on whether you compare average or median penetration. This illustrates just how much influence the broadhead you select has on your arrow's penetration potential.

The larger the game you hunt or the lighter the draw-weight of the bow you use the more important your selection of broadhead becomes, but **IN BOWHUNTING THERE IS NO SUCH THING AS OVERKILL.** Even on lighter big game there are times arrow setup will make the difference between a clean, humane kill and a wounded, non-recovered animal. **On a perfect hit virtually any arrow setup works. On bad hits your arrow and broadhead setup becomes critical.**

Next, let's do a comparison between this Ultra-EFOC arrow and the penetration-enhanced EFOC arrow from the 70# Longbow. This is of interest because both arrows have virtually equal impact force; 0.474 vs. 0.477 Slug-Feet/Second. Both arrows have the 190 grain Grizzly broadhead. Shaft diameters differ by only 0.016". While all test animals are of similar size those in the Ultra-EFOC group average somewhat larger. Shot angles and distances are the same.

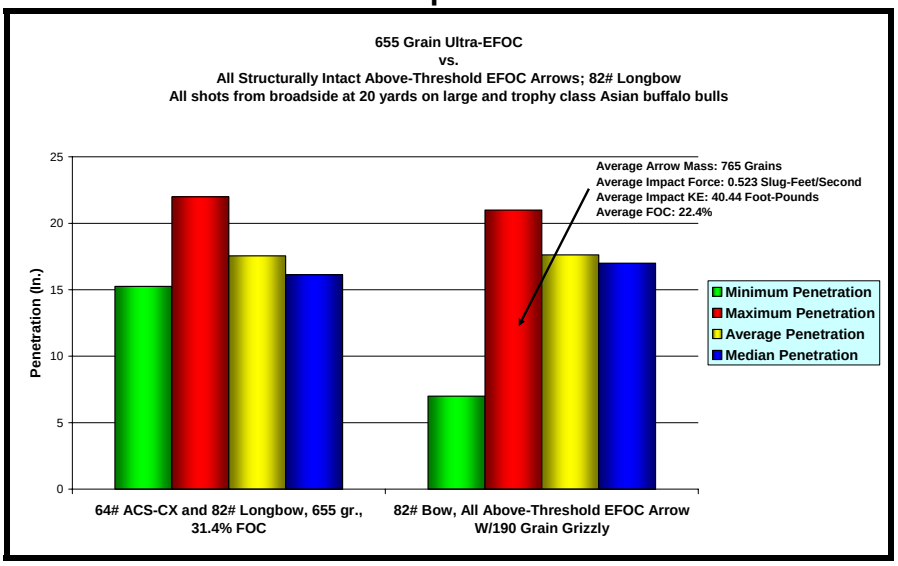
Graph 25



A look back at Part 3 of the 2007 Updates shows that this EFOC arrow from the 70# longbow gave a 100% bone-breaching rate on large and trophy size buffalo bulls. It bested the average penetration of the 82# longbow's comparable-shot Normal/High FOC arrows 'all single blades' group by a whopping 58.7%. It bested the 82# bow's 'same broadhead' group by 25.2%. The 70# bow's penetration-enhanced EFOC arrow is definitely high-performance. Nonetheless, at near-equal impact force, and when tested on only 'massive bodied" bulls, the 101 grains lower mass, Ultra-EFOC arrow averaged 12.1% greater penetration, while still giving a 100% bone-breaching rate on massive buffalo bulls.

Even though its mass-weight is just barely above threshold value the Ultra-EFOC is certainly holding its own against all higher mass, lower FOC arrows. How would it compare against just the 82# bow's above-threshold EFOC arrows having the same broadhead? Let's look.

Graph 26



Almost astonishingly, the average penetration between these two arrow groups differs by only 0.4%. Their median penetrations show only a 5.4% difference. The penetration range between minimum and maximum is far more consistent for the Ultra-EFOC arrow. **Terminal performance of the significantly lighter Ultra-EFOC arrow is not only essentially equal to than that of the 82# bow's heavier, matching-broadhead EFOC arrows, its performance is more consistent!**

Consider the similarities in external arrow dimensions between these two groups of penetration-enhanced arrows, and the differences in arrow mass. Think back to the 2007 Updates. The penetration gains shown by every EFOC arrow tested - whether

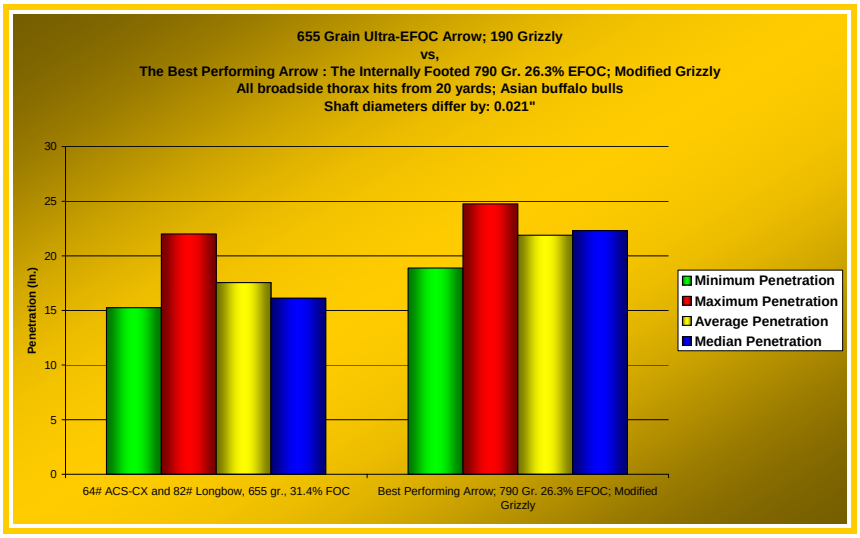
from the 54#, 70# or 82# bow - was remarkable, but Graph 26's implications for Ultra-EFOC's effect on arrow penetration is staggering.

Let's make one final comparison for this 655 grain Ultra-EFOC arrow. How does it compare against the arrow setup that has stood head and shoulders above all others tested; the Internally Footed, 790 grain, **Modified Grizzly tipped** EFOC arrow from the 82# longbow.

With this comparison we're introducing a major variable between the arrow setups; one that has a huge influence on penetration - the broadhead's mechanical advantage. When tested on Normal FOC hardwood arrows (where difference in wood density could be used to offset the 20 grains difference in broadhead weight), the Modified Grizzly demonstrated a percentage penetration increase that *exceeded* the percent of mechanical advantage increase. The Modified Grizzly's MA is 18.2% greater than that of the 190 grain Grizzly, but on equal-shaft/equal-mass setups it averaged 26% greater penetration.

This 'percentage of penetration-gain greater than the percentage of broadhead MA increase' is the result of increased arrow efficiency. As explained in the example in the 2008, Part 3 Update, additional retained force results in a greater time of impulse; and each, *force* and *time*, compounds the effect of the other. The result is a greater percentage increase in penetration than the percentage increase in the broadhead's mechanical advantage.

Graph 27



Graph 27 shows the comparative results of the 190 grain Grizzly tipped, 655 grain 31.4% Ultra-EFOC arrow against the Internally Footed, Modified Grizzly tipped, 790 grain, 26.3% EFOC arrow. This EFOC arrow bested the lighter weight Ultra-EFOC arrow's average penetration by 24.8%, but in this comparison there are many additional factors to consider for each setup.

Each of the 790 grain EFOC arrows not only penetrated the off-side rib, they carried on to provide an exit wound. For the Study's purposes penetration is defined as the length of the wound track through the tissue(s). All shots with this EFOC arrow showed a level of penetration that exceeded "measurable penetration". The actual penetration level for these arrows would be greater than the measurable penetration, and would exceed the Ultra-EFOC arrow's average penetration by more than the 24.8% shown.

On the other hand, when comparing against setups **with the same broadhead** the Ultra-EFOC arrow has consistently shown markedly greater penetration than heavier EFOC arrows. When tested on normal FOC setups, as near identical as possible, the Modified Grizzly has demonstrated a 26% penetration advantage over the 190 grain Grizzly. The penetration difference that can be attributed to the difference in broadhead MA (26%) exceeds the difference in 'measurable penetration' (24.8%) between the two arrow setups.

This leaves some nagging questions. (1) All thorax hits with the Ultra-EFOC arrow fully traversed the thorax and stuck solidly into the off-side rib. Would use of the higher mechanical advantage Modified Grizzly have allowed this slightly-above threshold Ultra-FOC arrow to retain enough force to breach the off-side rib? (2) If it did breach the off-side rib, would such a setup also provide exit wounds, giving penetration equal that of the heavier EFOC arrow? (3) What would be the performance of an Ultra-EFOC arrow having both the Modified Grizzly broadhead and the same mass-weight as the best-performing EFOC arrow? These are new questions for future testing.

In Part 6 of this Update series we'll look at the implication of these FOC test, and see if we can quantify FOC effect on penetration.