# 2008 Study Update, Part 4

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Testing has shown that the threshold of arrow mass for penetrating heavy bone lies somewhere very near 650 grains. This threshold value is little affected by changes in arrow force or the arrow's degree of weight forward of center (FOC). However, testing also indicates that once a bone is breached the degree of arrow FOC becomes a very important factor in determining the amount of post-breaching arrow penetration. This was dramatically shown by the bone-breaching shots with the below-threshold Ultra-EFOC arrows from the 40# recurve. The next question became: What would the performance of a penetration enhanced, above-threshold Ultra-EFOC arrow be?

When setting off into the more remote realms of Australia's Northern Territory for a few months of testing I try to carry a wide assortment of raw arrow components, just so I'll be able to build up arrows to meet the need for some unanticipated test series. Unfortunately the materials I had on hand in 2008 proved lacking in variety to make up an above-threshold Ultra-EFOC arrow for the 40# bow. I did, however, come up with components to make a 'just above threshold' Ultra-EFOC arrow that bare-shaft tuned to the 82# longbow. The up-side of this was the vast amount of shot data already available for the 82# longbow. Many different performance comparisons could be made.

This situation prompted a slightly different set of questions in evaluating the terminal performance of the Ultra-EFOC arrow. (1) If testing were stepped up to only the largest and most massive bodied bulls would this barely above-threshold Ultra-EFOC arrow still reliably penetrate the heavier ribs? (2) How would the post-breaching penetration of such an arrow compare with that of well tuned, but significantly heavier arrows having lower amounts of FOC?

Thinking that it would be nice to get a performance level for this arrow at more than one impact force it was decided to see if the arrow could be used on any of the several lighter draw-weight bows I had along too. After a bit of tinkering with the thickness of the arrow plate I managed to get this same arrow to bare-shaft correctly from a 64#@27" ACS-CX.

At first glance this may sound paradoxical. How can an arrow with the correct dynamic spine from an 82# bow also spine correctly from a 64# bow? Wouldn't the spine be far too stiff for the lighter draw weight bow? No, in fact the dynamic spine was initially too weak for the 64# ACS-CX. How can that be? The

82# bow is very far from center shot. Its sight window is cut nearly ¼" short of the bow's centerline. This means it requires a weaker spined arrow (relative to an equal bow cut closer to center shot). The ACS-CX is cut to the centerline of the bow, requiring an arrow with a stiffer spine. This difference, coupled with the higher performance level of the ACS-CX, allowed the same arrow to be tuned to each bow.

For any not familiar with the difference in degrees of center shot, a true center shot bow will have a sight window cut into the riser past the riser's centerline, to a depth equaling one-half the arrow shaft's diameter. This means the center line of the arrow is precisely in line with the bowstring. When a bow's riser is 'cut to center' the string will be directly in line with the cut, and the arrow's centerline will be positioned at a slight angle to the bowstring. If the riser is cut to less than center, the arrow's centerline will lie at an even more marked angle to the bowstring. Contrary to popular belief, a true center shot bow in neither inherently more nor less accurate than a non- center shot bow. With a properly tuned arrow any bow shoots accurately.

Unfortunately all the effort to get this arrow tuned to these two bows did not give the diversity of results I had hoped for. When chronographed, arrow velocity from the high performance ACS-CX proved to be identical to that from the 82# straight end longbow. Nonetheless it was decided to test the arrow from both bows.

**The 'Slightly Above Threshold' Ultra-EFOC Arrow**

**Arrow Setup:** Shaft: 7595 Gold Tip Expedition Hunter; 100 grain Brass insert; 125 gr. steel adaptor; 190 Grizzly broadhead; 2.5" A&A 4 fletch at 70-105; Arrow Mass: 655 grains; **FOC 31.4%**; Impact Momentum: 0.474 Slug-Feet/Second; Impact Kinetic Energy: 38.64 Foot-Pounds.

**The small 2.5" A&A pattern 4-fletch easily stabilized the Ultra-EFOC arrow's 190 grain Grizzly, even with a finger release as poor as mine. The higher an arrow's FOC the less fletching it requires. Reduced fletching size means lower weight on the shaft's rear and increased FOC. Small fletching also means less drag in flight, more retained arrow energy downrange, flatter trajectory, less arrow drift in crosswinds and quieter flight. Note the turbulator, the elevated red band ¼" forward of the fletching; and integral part of the A&A pattern.**

## Test Results

A total of 12 test shots were taken with this Ultra-EFOC arrow setup. All shots were from broadside at 20 yards on Asian buffalo bulls. Six shots were with the 82# straight end longbow and six with the 64# ACS-CX. Three of the shots with the 82# bow were on a very large bodied adult bull, and three on an *exceptionally* massive bodied trophy class bull. Five of the shots with the 64# ACS-CX were on a very large bodied adult bull, and one shot was on a trophy class bull of approximately the same body size. Since both bows gave the same arrow velocity and no difference in outcome performance was noted all shots are being grouped together as one set.

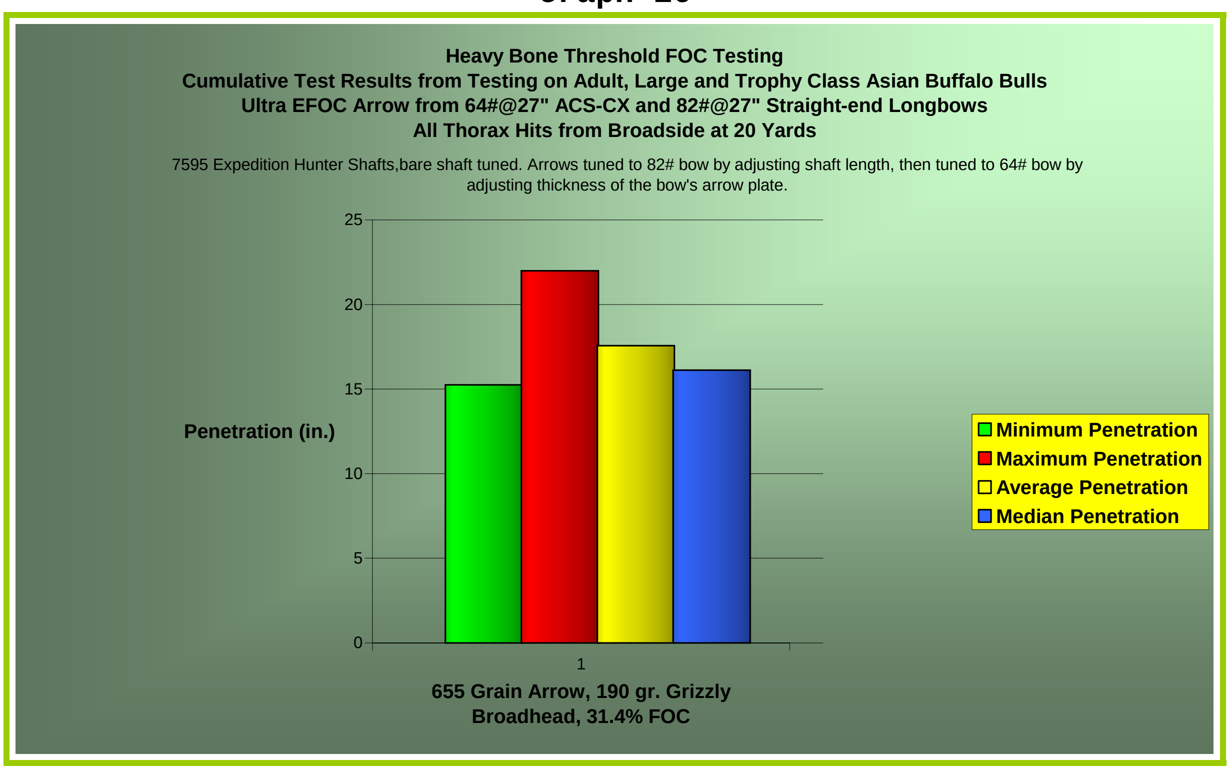
Two deliberate shoulder shots were taken; one with the 82# longbow and one with the 64# ACS-CX. The shot from the 82# bow was placed mid-shoulder on the over-sized trophy class bull. It penetrated the scapula and the several inches of heavily muscled shoulder, but stopped in the on-side rib. Penetration was 11.25". The shoulder shot with the 64# ACS-CX was on the very large bodied adult bull. It hit very low, striking center of the folded elbow joint. It penetrated the elbow joint and the on-side rib, passed through the lower portion of the heart and stopped in the off-side rib. This shot passed through the narrow, lower portion of the thorax. Penetration through the thorax was 10.5"; not including the elbow joint penetration.

Ten thorax-impact shots were attempted. One of the shots with the 64# ASC-CX hit very high, something that I can only attribute to my poor shooting. It struck the spine, totally burying the broadhead and severing the spinal cord. Penetration was 10.375". The remaining nine shots were well placed in the lower 1/3 of the chest, with each penetrating the entrance rib and fully traversing the thorax. Each shot pierced both lungs and stuck solidly into the off-side rib. None of the shots penetrated the off-side rib. Average penetration for these shots was 17.55", with a median penetration of 16.13".

## Comparing the Outcomes

Graph 16 depicts the outcomes for the nine thorax hits. It shows the maximum and minimum penetrations as well as the average and median penetration.

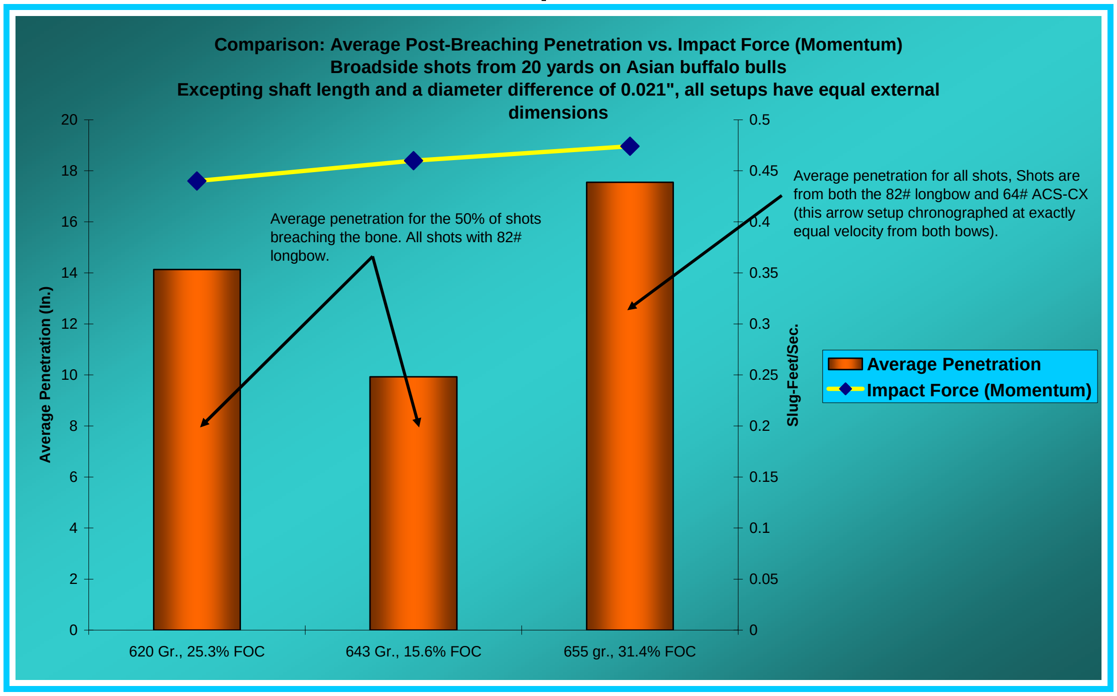
**Graph 16**



## Comparison to the 82# Bow's Below-Threshold Arrows

Since the impact force for this slightly above threshold Ultra-EFOC arrow is near equal that of the 82# bow's two same-broadhead below-threshold arrow sets (2008 Update, Part 3) lets compare against the results for their bone-breaching hits before we compare against the heavier, but lower FOC arrows from the 82# longbow.

**Graph 17**

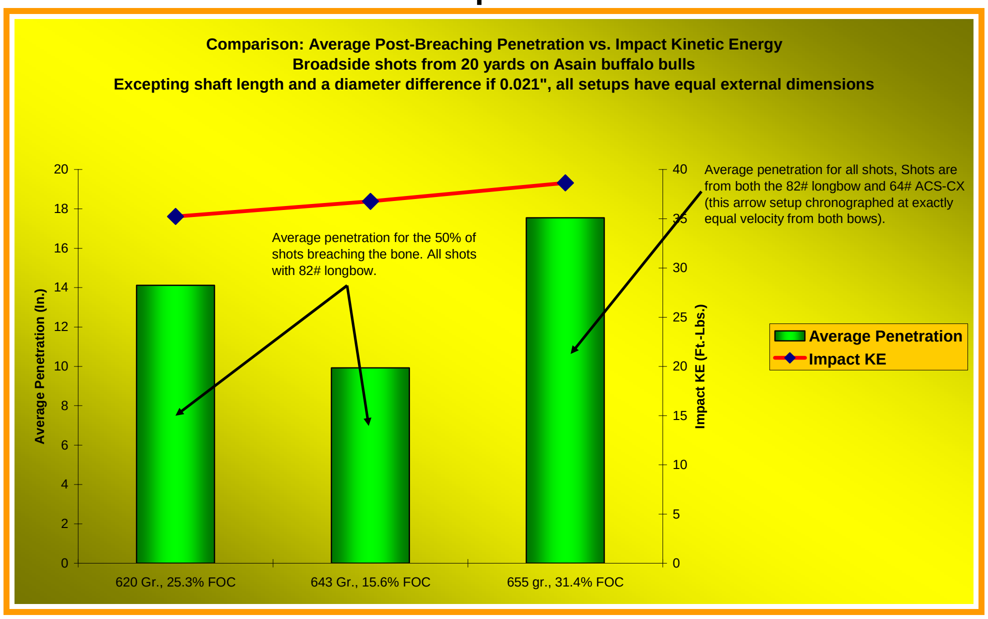



The bars in Graph 17 show the average penetration for the 50% of bone-breaching thorax shots delivered by the 82# bow's two sets of below-threshold arrows and the average penetration for all thorax shots in the slightly above-threshold Ultra-EFOC arrow set. The blue diamonds along the yellow line show the impact force (the arrow's momentum at 20 yards) for each set of arrows. The extreme spread of arrow weights is a mere 35 grains and all three setups have the same broadhead; the 190 grain Grizzly.

In this test sequence the Ultra-EFOC arrow has a shaft diameter that is 0.021" smaller than that of each below-threshold set. Though the difference in impact force is slight, the Ultra-EFOC arrows show both the characteristic abrupt increase in the heavy-bone penetration rate that comes with arrow weight above threshold and a marked increase in post-breaching penetration. The difference in bone-breaching rate is merely one more confirmation of the Heavy Bone Threshold's presence, but what do the post-breaching penetration results indicate?

Compare the result shown here with those depicted in Part 1's Graph 4, and Part 3's Graphs 11 and 15. Do you see the consistency of results? Whether comparing EFOC to high FOC or Ultra-EFOC to EFOC, as the degree of arrow FOC increases the amount of post-breaching penetration also increases, and by a significant degree. This trend has been present in each and every assessment of comparable shots.

**Graph 18**




Graph 18 shows the relationship between these same setups and the arrow's impact kinetic energy at 20 yards. This is provided in deference to any who still believe that an arrow's kinetic energy somehow indicates the arrow's penetration potential.

Here we have arrows of near identical external dimensions and near equal impact kinetic energy. Other than shaft length, the only difference in their external dimensions is the 0.021" smaller diameter of the Ultra-EFOC arrow's shaft. The maximum difference in arrow mass is a mere 35 grains. **If kinetic energy alone is the predictor of arrow penetration why do they not have near equal penetration?**

The two below-threshold sets have equal shaft diameters. These two setups differ only in shaft length and 23 grains of mass. Why does the setup with slightly lower impact KE show a 42% increase in average penetration? Why does the above-threshold set, with only marginally more impact KE, show a 24.2% penetration increase over the 620 grain below-threshold arrows, and an enormous 88.4% increase over the 643 grain set?

Before someone says, "But Graph 17 shows the same relationship for the impact momentum. It didn't predict the penetration either", let me refresh your memory.

From the 2004 Update, Part 2: "*All* my data from shots into real animal tissues, to date, is also highly suggestive that the greater the contribution of resident arrow mass to impact momentum the greater the penetration in real tissues will be, **when all else is equal**. In other words, all the information I have from shots on real tissues indicates that when two arrows, **identical in all aspects** except their physical weight, hit identical tissues with equal amounts of force, the one deriving the greater amount of that force from the weight of the arrow will penetrate deeper." (Emphasis added)

From Part I of the 2007 Update we have: "While impact momentum cannot be used as a stand-alone predictor of penetration it does show *positive correlation* with outcome penetration; it demonstrates *relevancy*. This means impact momentum can be used as a *predictive function* **when all other arrow penetration factors are constant.**

"**With a constant arrow**, real tissue data confirms: Average tissue penetration increase is *directly proportional* to the increase in *impact momentum"* (Emphasis added).

Even with a 'constant arrow' impact kinetic energy has failed to demonstrate any direct proportionality with arrow penetration. Another way to state this difference is: (1) if you increase the impact force (momentum) of a given arrow by 20% the average penetration *into fresh, real tissues* shows an increase of 20%; (2) if you increase the impact kinetic energy of a given arrow by 20% the average penetration in real tissues *does not* show an increase of 20%, it shows a percentage increase that equals the percent of change in the arrow's impact momentum.

**The point I'm trying to get across is that *every single feature of the arrow's design has a penetration effect*.** The degree of arrow FOC is no exception. Indeed, it is proving to be a very significant soft-tissue and post-breaching penetration factor.

There is no more invalid question in bowhunting than, "How much kinetic energy do I need to hunt a … "(you fill in the blank). If you know an arrow's mass and its KE you can calculate its force (momentum), but unless you also know the exact specifics of the arrow setup and tuning, and also exactly how, and to what degree each of those specific features affects terminal performance such a question is totally unanswerable.

A better question would be: "This is my arrow setup. It's tuned for perfect flight. What level of arrow force is adequate to hunt a …." However, this is still not the right question. What will be the conditions of the hit? The terminal performance your arrow will need on that mystical 'perfectly placed shot' will not be adequate on many other hits *that might occur*.

**In my experience as both hunter and guide a 'perfect hit' is almost as rare as feathers on a frog. Regardless of the bow you chose to hunt with, the best question to ask is: "This is the bow I'm using. What arrow setup will give me the best chance of making a clean, successful kill *on as many of the potential hits as possible* when hunting a …". That's the arrow setup you want to use; the one that gives the highest probability of success, no matter what the hit. When it comes to hits try for the best, but prepare for the worst.**

In the Part 5 Update we'll compare the performance of this penetration enhanced 655 grain Ultra-EFOC arrow to that of all other arrows from the 82# longbow, including the super-heavy 'classic buffalo arrows'. Prepare to be astonished.