2007 Study Update, Part 2

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Misconceptions

Next to a sharp broadhead, most bowhunters seem to think shot placement is the most (and sometimes, OLNY) important thing in making consistently clean bow-kills. That's not true.

Considering only the non-buffalo records, Study data contains a number of extremely well placed hits that ended up non-lethal. All were with heavy draw-weight bows. Though most were on the ribs of larger animals (zebra, wildebeest, etcetera; comparable to elk/moose size), some occurred on animals as lightly built as whitetails, nyala and small to average size pigs.

None of those shots hit any bone heavier than a rib. They all occurred with 'good arrows', having shaving-sharp broadheads, perfect flight and sufficient impact force. The vast preponderance occurred on oblique impacts, but some were broadside shots. The glaring commonality among these well-placed failed-shots is that, with only one exception, each showed structural damage to some portion of the arrow system.

Any structural failure, occurring anywhere in the arrow system, wastes massive amounts of arrow force. It commonly results in non-lethal hits, even when the shot is well placed. A sharp broadhead is a given; no one should be hunting with anything less. However, in terms of terminal performance even broadhead sharpness does not rank as the most important hunting arrow feature. How sharp your broadhead is becomes irrelevant if it never reaches vital areas.

Data leaves no doubt: *When it comes to arrow lethality arrow penetration is the first requirement; the most important hunting arrow feature.* Among all factors affecting arrow penetration, structural integrity is the most important; period. If a point bends, an adaptor or insert gives way, or a shaft cracks, bends or breaks at impact it destroys penetration. If your arrow doesn't penetrate, that shaving-sharp broadhead never has a chance to do its work.

Second to arrow integrity is quality of arrow flight. It's second because a perfect-flying hunting arrow fails if the arrow crumbles when it hits. It comes before the other performance-maximizing factors because poor flight destroys the potential advantage other factors *could* give.

How accurately the hunter can shoot comes far down the list; past everything that improves how your arrow works. Yes, I know the old adage, "You can't kill it if you can't hit it", but there's a flip side. I can hit any large animal almost anywhere I choose with a pellet rifle … but I'll guarantee it ain't gonna die from the shot! What you hit with must be capable of killing *on the hit you make* – whatever that hit may be.

If you're clairvoyant, knowing exactly where and how every animal will be positioned when your arrow arrives, and a flawless shot with unimpassioned nerves, capable of placing every arrow precisely where your mystic mind foretells you that animal's vital area is going to be when your arrow finally does arrive, you'll have *less* to worry about. But for us mortals, the arrow we choose to use is highly important, and can make an enormous difference in the percentage of our hits that result in clean kills.

Which is more lacking, hitting game or turning the hits we make into kills? The answer is in the wound-loss rate. Far more game is hit than killed. All shot placement? More shooter accuracy would cure that? Neither Study data, wound-loss studies nor logic support that answer.

Unlike a target shot, which is static, the hunting shot is dynamic. The hunter can't control how the animal reacts. His target doesn't always remain where it was when he released his arrow. Neither can he always control other shot-factors; shooting position, angle of the target, shooting angle, length of draw he can achieve, time available to take the shot, intervening obstacles … and jittery nerves, to name but a few.

For us mortals, hunting shots are difficult (impossible?) to make perfectly *every single time*. I've hunted a bit, and guided a bit. I've seen almost every conceivable setup in action. I'd say that *at least* a third of all the hits I've witnessed clients make were marginal to poor; and darned few were 'perfect'. That being the case, is it not prudent to use an arrow setup capable of converting as many marginal and poor hits into clean kills as possible? There's no down-side to doing so. If your hunting arrow is designed to work when everything goes wrong, I'll personally guarantee it will work on every perfect hit too!

Too many hunters seem concerned with the amount of blood they see on the ground following a hit. The degree (amount) of blood trail left by different types of broadheads is still under intense investigation. However, so far data does not support the contention that the degree of blood trail has anything to do with cut size or the number of blades a broadhead has.

Data suggest that the degree of blood trail is most dependent on: (1) location of the entrance wound; (2) presence or absence of an exit wound; (3) location of any exit wound and; (4) what organs were hit in between. Regardless of that, the amount of blood on the ground isn't always a good criterion of how effective an arrow has worked. Even a small, non-lethal surface wound sometimes leaves a heavy and consistent blood trail on the ground; sometimes for miles. Think of how much you bleed from just a minute shaving cut!

To be quickly fatal bleeding needs to result from the penetration of vital internal organs. The more of these your broadhead passes through the quicker the shot kills. The greatest aid to animal recovery is *certain lethality* on every shot where your arrow's path will eventually intersect something vital … if it penetrates deeply enough to reach it. This results in a shorter trail, leading to a downed animal; and a *short* blood trail is the greatest aid of all in animal recovery, regardless of its degree.

With the forgoing in mind, let's continue our journey through the newest Study results; searching for the ultimate hunting arrow. We'll begin with a look at efforts to develop a stronger carbon shaft. The need for these will become clear as you venture through the subsequent updates.

Arrow Shafts

A lot of verbiage is tossed about regarding the strength and durability of synthetic shafting. It's even been stated that *no* wood shaft can be shot off a compound; they simply blow-up when shot, and splinter whenever hitting anything remotely solid! During the years I've used them, in both hunting and testing, neither of these has occurred once with my compound and Forgewoods; or any other *hardwood* shaft, for that mater.

Contrary to popular belief, Study results show *hardwood* shafts are 10 times *more durable* on hard and angular bone-impacts than either carbon or aluminum; regardless of what bow they are shot from. Hardwood excludes PO cedar and the other softer arrow woods; and refers to hickory, ash, laminated birch, ipe, purple heart, and Forgewood.

The Study's impact-damage rates (through 2006) are: 3.2 per hundred shots for *hardwood* shafts; 31.8 per hundred shots for carbon shafts; and 33.6 per hundred for aluminum shafts. Each above rate reflects only impact-damage. It comes from only static shots; those into freshly downed animals. This automatically excludes all possible animal-inflicted arrow damage.

If you consider only the lighter built animals, overall shaft-damage rates are somewhat lower, because of their less sturdy ribs. Recent Study Updates have concentrated on buffalo testing, but Study data goes back a quarter century and many lightly built animals are represented therein. For heavy-bone hits on those lighter built animals; scapula, humerus, femur, spine, skull or pelvis; the damage rates are fully comparable to that shown by buffalo ribs. The heavy bones of lighter built animals damage arrows just as frequently as buffalo rib-bone hits.

Angular bone-impact increases the likelihood of shaft damage. Bones are rarely flat. They are a combination of cylinders, domes, radius curves, spheres and arches. Most have surfaces simultaneously curving in several directions. Bone impacts nearly always occur at an angle, even on broadside shots. This is exactly as Mother Nature intended. Bones are there not only for support, but to protect from impact or penetration by deflecting and redirecting impacting force(s).

On any hit, the likelihood of angular bone-impact exceeds the chance of square-on impact. That's one major reason artificial-medium testing is of no use whatsoever for predicting outcomes on real-animals. *Artificial mediums lack the infinitely complex, yet highly organized matrix of multidirectional force-deflecting hard surfaces encountered in real tissue(s).*

With synthetic shafts you can expect about one-third of forceful angular and/or hard-bone hits to result in damage to the shaft, insert or broadhead adaptor, even with 'best' broadheads. That's a high percentage of potentially lethal hits which are impending failures.

Many hunters don't realize how commonly shaft damage occurs. Even when noted, it's often attributed to the animal-inflicted category; or written off as 'no arrow is a bone-breaker'. That's incorrect. The best arrow setups penetrate or break quite heavy bone with astonishing regularity.

The high damage-rate for *all* popular non-hardwood shafts is a chief reason folks believe 'no arrow is a bone breaker'. Other major reasons include poor bone-performance broadhead choices and widespread use of low-mass arrows; below the heavy bone threshold.

The New Study has little PO cedar data. It's difficult to get the mass of PO cedar arrows above the heavy bone threshold; especially at my draw. That's the primary reason the Study has used no PO cedar shafts since the Natal Study; except for a few with hardwood footings. However, those early test results do show a high damage rate for PO cedar shafts.

The need for a better carbon shaft

Personally, durability of synthetic shafts was a non-issue until the last few years. For serious hunting there were Forgewoods and other hardwood shafts. Extreme FOC arrows changed that mind-set. They show massive increases in penetration-potential … whenever there is no structural failure. The magnitude of that increase will become apparent in the following Updates in this year's series.

Though Extreme FOC arrows offer increased penetration potential, that potential can be relied on *only* if their shafts are as durable as hardwood; or at least very, very close. Otherwise, potential gains are severely offset by the high structural-failure rate.

Carbon shafts make the most easily developed Extreme FOC arrows. Double-shaft carbons are durable when fitted with steel or brass inserts and steel adaptors, but are not suitable for Extreme FOC. Unless substantial weight is added behind the insert, they simply have too much weight towards the rear.

The long trail

Three years of effort has been poured into strengthening carbon shafts while allowing easily attained Extreme FOC. After much trial-and-error testing, and the intentional destruction of many pricey carbon shafts on armor-plate, it appears there is an answer.

Long brass (or steel) inserts and steel broadhead adaptors have shown a reduction in direct-impact breakage. However, they show little advantage on angular impacts. On these, with annoying frequency, shafts tend to fracture back of the insert. Durability is far below hardwood shafts.

Attaching a long section of doweling or smaller diameter shaft into the arrow's fore-section didn't prove effective. It virtually stopped direct-impact (compression) fractures, but forceful angular-impact simply broke the shaft at the reinforcement's rear, rather than behind the insert. The shaft's weak-point was merely shifted further back. The same is true for carbon shafts strengthened by adding a sleeve over the shaft's outside forward section; externally 'footing' the shaft.

An ideal reinforcement would require a combination of structural aspects. The concept was simple.

First, the reinforcement had to provide a strong coupling of the insert to a greater portion of the shaft; transferring direct-impact force to sufficient bearing-area to dissipate compression force. In effect, the shaft's front needed to be a solid structure, strong enough to absorb the 'crushing blow' delivered by the hard frontal impact and the 'push' exerted by the shaft's rearward mass.

Second, the reinforcement had to provide a graduated degree of support behind this area of solid support. On angular impacts, it had to redistribute the flexional forces created by both the deflection and the shaft's trailing rearward mass; spreading them over a longer portion of the shaft. This it had to do in a controlled fashion.

Along with how to achieve these features, a few questions had to be answered: How long did each section of the reinforcement need to be to achieve the desired force-redistributions, and what total reinforcement length would that require?

Using a solid reinforcement back of the insert merely shifts the shaft's weak-point further back along the shaft, as shown by this shaft's angular-impact fracture.

Somewhere along the line, while brainstorming design concepts and discussing with several engineers and very knowledgeable bowhunters about how to accomplish these features - and long before the first prototype was made - the reinforcements picked up the name 'Internal Footing', or IF, for short.

Before continuing the IF saga, let's look at shaft damage during 2007 testing. It contains few surprises.

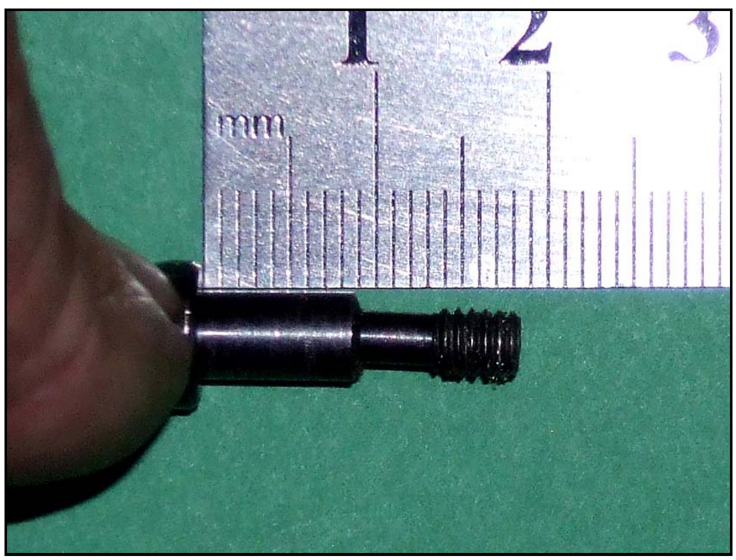
Shaft usage and breakage; 2007

Extreme FOC was a focus, and the bulk of shafts used were carbon. However, hardwood shafts were used for much of the broadhead testing. Hardwoods comprised 19% of shaft usage, with 43.8% of their shots being deliberate adverse-angle impacts into scapula and/or leg bones. No hardwood shaft was damaged.

Eight percent (8%) of shots were carbon-carbon double shafts having long (100 gr.) brass inserts and steel broadhead adaptors. Twenty-five percent (25%) of these were adverse-angle heavy bone impacts. None were damaged.

Six percent (6%) of shots were carbon-carbon double shafts having aluminum inserts and steel adaptors. All were broadside rib-impact shots. One shaft was broken back of the insert; with both insert and adaptor bending. This shot, an arrow of 1119.5 grains with a 125 gr. Ace broadhead, failed to penetrate the entrance rib. It yielded the first bent steel broadhead adaptor recorded in the Study. We'll discuss this shot in greater detail in the broadheads section.

This 1119.5 gr. double-carbon shaft broke behind the aluminum insert, failing to penetrate the entrance rib.



Both the aluminum insert and the steel adaptor's shank were bent. This is the first bent steel adaptor recorded in the Study.

Aluminum/carbon double-shafts with aluminum inserts and steel adaptors were used for 6% of the shots. All were broadside, back-of-the-shoulder. None were damaged.

Normal carbon shafts comprised 41% of total usage. Aluminum inserts were used on 43%, with the balance having brass or steel inserts. Steel adaptors were used on 31.7%, with the remainder being aluminum. Though 95.2% of the shots were broadside with rib-only bone impacts, 31.9% suffered shaft fractures. Results are exactly as the Study's previous damage-rates forecast (31.8/hundred shots).

Among carbon shaft fractures, 86.7% were associated with bone impacts that halted penetration. This illustrates one Law of Physics: during a full-stop collision all force(s) must be dissipated. Slam … all force is used up quickly. This short time of impulse means a high peak force.

Think of slamming your car into a solid wall at 102 mph (164 kilometers/hour). Though of greater magnitude, it gives an idea of how a fast-stop force-curve looks at 150 ft/second. This should give you a mental picture of just what we're asking of our arrows, and what stress they encounter on any hard impact. It's of little wonder that the damage rates are so high! In cases of hard impact the weakest item suffers the most damaged; be that broadhead, insert, adaptor, shaft … or the bone. It is here that arrow strength becomes absolutely crucial.

A shaft worthy of the game

Carbon shafts with several differing IF's were tested. All had some common features, but there were significant differences. The IF's were of several materials. All had a solid fore-section, but varied in how progressive flex was achieved along their rearward length.

Internally Footed carbon shafts comprised 20% of all test shots. All had Extreme FOC. Nearly all were adverse-angle heavy bone impacts against leg bone; at or immediately below the shoulder joint. This was stress testing. Only one set was used for broadside chest shots. That information will be presented with the Extreme FOC results.

No IF shaft was damaged. Results *strongly suggest* the IF design-concept provides major strengthening to carbon shafts. Buffalo testing was intended as a trial run of all IF designs showing good performance in the armor-plate testing. It was hoped one or another of the various IF *internal designs* (intended to provide progressive flex, dissipating the oblique impact forces) would show a distinct advantage, however, they all worked.

Passing the buck

As a question remains as to which design worked best, all that can be provided is generalized information. Detailed design information and test results have been passed to a shaft manufacturer. It appears there's interest in making commercially-available IF's. The information is now in the hands of material, structural and design engineers. With hard evidence that the concept does work, computer modeling should indicate which material and design best spreads lateral and oblique impact forces along the shaft.

[Yes, the Internal Footing information was freely passed along. The Study remains unencumbered by any personal gain. And, contrary to suppositions repeatedly alleged by some, none of the Study cost is tax deductible, either. Doing the Study *definitely* is not merely a way for me "to hunt for free". In fact, collecting Study data *drastically increases* the cost of every hunting trip I take, by many fold. I can't have just a single arrow setup; I need many dozens of different ones - and the ones needed are constantly changing! It adds up fast.]

Genesis of the Internal Footing

As possible commercial development of an IF is in progress some of the construction details are being withheld for the time being. If commercial development does no come to fruition, a detailed description of IF internal construction required in order too achieve the necessary rearward progressive flex will be presented in a future Update.

After a bit of experimentation, the overall IF length required was easily reached. However, early test showed that glue-attaching the entire IF's to the outer-shaft wall didn't work, regardless of flexional-design. Full attachment inhibited progressive-flex. Some degree of slippage between the IF's rear and the inner shaft wall during flexion appears necessary.

The original question returned: What portion of the IF's length had to be anchored to the shaft and insert to provide enough strength to halt compression fractures? Determining the amount was costly, resulting in the destruction of more shafts than any other development-phase. By trial-and-error the answer was determined. Testing was at a fairly high impact force; around 0.53 Slug-Ft/Second, but IF's of the length settled on might prove insufficient at higher levels. I haven't tried it, so don't yet know. Overall arrow length *may* also prove to be a factor, but that doesn't seem likely. Initial testing was done with shafts all the way up to full length (required in order to get perfect bare-shaft flight with some of the shafts tested).

Assembly

JB Weld was used for the attachments. The shaft wall was thoroughly cleaned with isopropyl alcohol and swabs, until the swab came out *totally* clean. Inserts were cleaned with commercial degreaser, followed by isopropyl alcohol, then boiling water (de-mineralized; available at most supermarkets, for use in steam irons). Rubber gloves were used to prevent incidental skin contact that might inhibit adhesion. IF's were cleaned by various methods, depending on the material.

One IF variation was made from a solid hard-nylon rod. Firm adhesion required adding annular glue-grooves along the rod's forward area of attachment. A reverse-cone cavity was also required at the rod's front, to provide a dead-man anchor for the JB Weld's attachment of insert to IF. In early trials, adhesion wouldn't hold without these.

For the proposed factory IF's, it has been suggested that a threaded portion be added at the IF's front, so that it can be screwed into the back of a brass or steel insert. This would make instillation easier. The insert and IF could be installed as a single unit. However, the design engineers are also looking at the possibility of some potentially-usable materials that would permit the insert and IF to be manufactured as a single unit.

The IF's are *very* tedious to construct. That's a big reason for passing the information to a shaft manufacturer. It would be far easier to manufacture an IF in the proper configuration than to fashion them by hand.

Use of aluminum inserts and/or adaptors negates much of the IF advantage. They should be used with brass or steel. Use of aluminum inserts on the IF shafts resulted in frequent shaft-cracks, even with steel broadhead adaptors. Close examination *suggested* the aluminum was compressing. After a single hard-impact shaft bulges were visible on some non-cracked shafts; immediately over the insert and at the insert's rear, but forward of the IF's firmly-attached solid fore-section. After several shots, it was visible on most shafts that had not cracked.

Up, Up and Away

Perfect flight proved easy. The Internally Footed shafts were treated like any other Extreme FOC arrow. However, there is one notable exception. IF's shorten the shaft's working-section, shifting the center of pressure (CP) during flight. (CP is the actual point used to calculate the true FOC for objects in flight, and during launch; see Prologue to the current Updates.) It was necessary to weaken shaft spine considerably.

Even with massive point weight, overly-long 60-75 shafts were usually required for perfect bare shaft flight from bows in the 80# to 90# range. On many, 45-60 shafts worked better. Most notable, an aged Howard Hill 85# bow required long 45-60 shafts with 465 grains up front (including IF).

Nearly all 'normal length' 60-75 IF Extreme FOC arrows shot strong-spine from bows up to 90#; but not all. Pertinent factors for consideration though: (1) none of the above bows are anywhere near center-shot; (2) none are 'high efficiency' bows and; (3) these were at a 27" draw. However, for making an IF shaft of normal-length, it appears the outer shaft you start with should be somewhat less stiff to give correct dynamic spine.

For Extreme FOC arrows, reducing required shaft stiffness is all to the good. It allows reduced weight towards the arrow's rear, boosting the FOC. Considering what the Extreme FOC results *suggest* - that outcome penetration continues to increase as the amount of FOC gets greater, at least up to the 30-plus percent level that's been tested - that's a 'win-win' situation.

At the moment, developing an IF shaft is a lot of trouble, but it's won't be nearly as difficult if an across-the-counter Internal Footing materializes. Currently, it appears that emergence of a factory produced version of the IF is likely to happen very soon.

In the next Update we'll begin looking at both IF testing and the newest FOC test-results. All the new Updates have many things that *should* be of importance to all hunters, and with special import for both those hunting the larger animals and those hunting with bows of lower draw weight; especially Parts 3,4,5 and 8. Hold on to your hats!