By Larry Wise

# Controlling Dynamic Arrow Spine

Arrow shaft spine pertains to the bending and recovery properties of the material that makes up that shaft. As archers, we have to learn how to control this bending to our advantage so we can get the arrow groupings in the target that accurately reflect our archery skill. In other words, we want to have fun shooting our bows and arrows. After shooting arrows for over 50 years, I still get a kick out of watching the flight of an arrow but it's always extra special if that arrow also hits the middle.

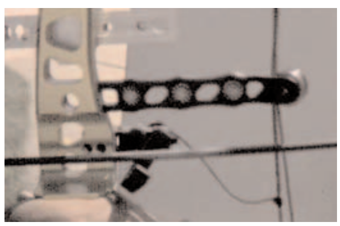
Controlling an arrow shaft's dynamic spine (its in-flight bending) is something I've done for years. Controlling this three-dimensional bending involves a wide variety of details that affect the ability of the shaft to bend, recover from that bending, establish free flight and then fall into the target at the end of its parabolic arch. Knowing a little about these details and tuning strategies will help you serve your customers and so I've outlined them in the following article. Doing a better job matching a shaft's dynamic spine to the bow setup will make your customers happier and, when they keep returning to your business, you'll be happier, too.

**STATIC SPINE:** The **at-rest measurement** of a shaft's stiffness is called static spine. This measurement is the distance that a 28-inch shaft bends when a 1.94 pound (880 gram) weight is placed at the shaft's center. This measure is recorded in thousandths of an inch and often appears printed on shafts. For example, the spine measure 440 would mean that the shaft would bend .440-inches at its center if a 1.94 pound weight were hung midway between two supports placed 28 inches apart (26 inches and 2 pounds are used for wood shafts).

By the way, I shoot a shaft with a 440-spine rating but the static spine value is just the beginning. I have to fletch the shaft, put a nock in it, put a point in it, nock it on the bowstring, place it on an arrow rest, draw and shoot it. Now it gets interesting because everything involved is in motion! Now we're talking about DYNAMIC SPINE!

**DYNAMIC SPINE:** The **bending and recovery properties** of a shaft during its flight is Dynamic Spine. We can't measure it but we sure have to deal with its effects on the arrow and how well all of our arrows group in the target. It's almost as if this moving, vibrating object takes on a life of its own during its time in flight and, sometimes, it defies us to find a way to control it. However, most of the time we can control it by following a set of strategies that affect the dynamic spine. These strategies begin with the selection of shaft size, making of the arrow, arrow rest type and adjustment, nock fit, D-loop style and long-distance fine-tuning. You can use this article as a checklist for your customers and for yourself.

***At Lancaster Archery, "Moose" Whitmoyer uses the spine tester by RAM Products to check the spine consistency of a dozen shafts. The device supports the shaft at two points 28 inches apart while a dial indicator measures the shaft deflection at its center caused by a 1.94 pound weight.***



***Both aluminum (right) and carbon arrow shafts bend the instant the string begins to drive them toward the target. They bend because the lighter nock-end moves first while more force is required to move the point. The carbon will bend and recover at a faster rate than the aluminum because of its higher modulus.***

## SHAFT CONSIDERATIONS:

Several factors affect how **stiff or weak a shaft** will act in flight. They are diameter, wall thickness, material, length, and profile.

**A) DIAMETER:** Most aluminum shafts are marked with their diameter. An example here is the 2612 shaft


*Many shafts have their spine rating printed on them for reference. You can see that these values are printed as inches-of-deflection-from-straight and, for these examples, range from a low of 340 to a high of 410 for the X-10 shaft. Choosing the spine value appropriate for your set-up is the first step in arrow shaft tuning. Also note that the X-10 shaft is fatter just behind its middle which gives it different bending characteristics than the more common parallel or true cylindrical shafts.*

where the first two digits, the 26, is the shaft diameter in sixty-fourths of an inch. Carbon shafts don't have this marking and you may have to actually measure with a caliper to find out. Most roll-wrapped carbon shafts have the same inside diameter, .243" or .244", as the ACC carbon-aluminum 3-60 with their outside being in the range of .285" to .300". Some are larger to satisfy the indoor and 3-D archers while carbon-aluminum shafts like the X-10 are smaller.

**In general, the larger the diameter the stiffer the shaft and the less it bends. Therefore its spine measurement would be lower and it would be more suited to a higher draw weight bow. Shafts are just like people, the swifter the kick in the behind the more they bend!**

**B) WALL THICKNESS:** Using the aluminum shaft example of 2612 again we find that the last two digits, 12, would correspond to the thickness of the aluminum wall. In this case it would be twelve thousandths of an inch. A 2613 would have a thicker wall and would be stiffer than the 2612. This would also hold for carbon shafts that are thicker walled.

**C) SHAFT MATERIAL:** The shaft material makes a big difference in how the arrow shaft bends and recovers.


*Most aluminum shafts have a four digit numeral printed on them to indicate both diameter in 64ths (first two digits) and the wall thickness in thousandths (last two digits). Printed on other shafts you can see the approximate peak draw weight for which the shaft is best suited. The 45/60 means this bottom shaft is spined for draw weights ranging from 45 to 60 pounds.*

Aluminum is stronger and stiffer than wood and carbon is stiffer than aluminum. Not only are the strength properties different their recovery properties vary as well. Carbon oscillates faster with less deflection-from-straight through its bending and recovery than does aluminum, which means that carbon can recover from its initial-thrust bending in less time provided that all other construction characteristics are held equal.

This recover-rate property is also true for carbon at impact. The carbon vibrates less side-to-side than aluminum on impact and therefore delivers more of its energy in-line. The net result is more penetration. I notice this with my target arrows in practice when I change distances and forget to change my sight – the carbon arrows penetrate all the way through the treated lumber around my target butt while the aluminum only go half-way!

**D) SHAFT LENGTH:** Most archers understand that a longer shaft will act weaker (bend more during the initial-thrust) than shorter shafts of the same size and shape. Although static spine is measured across a 28-inch span, dynamic spine affects the entire length whatever that may be. For that reason many indoor archers use full-length large-diameter aluminum shafts to match their 45 to 50-pound indoor bows.

Carbon and carbon-aluminum shafts have this same property – longer acts weaker – and many archers cut these shafts in ¼ inch increments while holding point-weight constant to achieve a desired spine. This is a technique used mostly for long distance FITA shooting.

**E) SHAFT PROFILE TYPE:** Most shop owners only deal with the cylindrical or parallel shafts. That's what most hunters, 3-D and target shooters use. The Easton X-10 shaft has a "barreled" design. That is, it has a fatter diameter just behind its center than at its ends (I've also seen back-to-front straight-line tapered shafts). Centuries ago the Turks used the barreled shaft to increase the distance an arrow could fly by taking advantage of the "lift" property of the shape. Actually, the barreled design has less drag than a cylindrical shaft and, therefore, less velocity decay during its down-range flight and that's what interests those shooting 90 meters.

## FLETCHING CONSIDERATIONS:

As soon as we begin building an arrow from a bare shaft we change its dynamic characteristics. In other words, we change how it bends and recovers from that bending by adding weight at various positions along the shaft. When we apply a force to the back-end of the arrow in order to propel it to the target we must deal with what Sir Isaac Newton stated as his first law of motion: An object at rest or in motion will stay at rest or in motion unless acted upon by a force.

In the case of the arrow we are applying a force to an object at rest and that arrow will tend to stay at rest until the string begins to push it at the nock-end. Weight now becomes an important factor as the point, usually being the heavier, tends to stay at rest longer than the lighter weight nock-end and, thus, the arrow shaft is forced to


***The nock and 4-inch vanes I use on my hunting arrows weigh 36.8 grains and make my Phantom carbon shaft act stiffer because they are mounted on the nock-end. The target nock and vanes weigh 25.6 grains, which is enough of a difference to affect how much point weight will be needed to get the best groups.***

bend to accommodate this condition. We just can't escape the laws of physics – Sir Isaac was right and every arrow we shoot verifies that fact as it bends.

**A) FLETCHING WEIGHT:** Adding fletching to the nock-end of the shaft adds weight to that end and affects the dynamic bending of the shaft. Weight at the nock-end makes the arrow act "stiffer" or bend less during the initial-thrust of the string. Bigger fletching adds more weight (4 inch vanes = 8 grains each, 1.75 inch = 3 grains, 4 inch feathers = 2.9 grains.) and the arrow acts even stiffer but if your purpose is to shoot broadheads then you need the increased surface area of those bigger vanes or feathers and you must tune the arrows accordingly.

**B) FLETCH ANGLE:** Gluing the vane or feather in place so that it is in-line with the shaft will yield minimum stabilizing effect. Without one side turned slightly toward the direction of flight the shaft will not be guided consistently to the target. Consider the baseball pitcher who has a good "knuckle ball". The ball has no spin to establish a set direction and the poor hitter and catcher have no idea where it's going. We must install the fletching with a set angle to the shaft length to provide a set direction as the arrow recovers from its bending. Two degrees for smaller carbon shafts and more for the fatter shafts is what I recommend.



**C) FLETCH SHAPE:** Vanes and feathers come in many shapes and sizes. Most are parabolic while others are shield-cut having a sharp cutoff at the back end. Fletching can have a low, medium or high profile depending on how much surface area and weight you want or need on the nock-end. Higher profiled fletching will have more surface area and aid the arrow in its in-flight recovery from bending but will increase velocity decay at long distance. (Shot any flu-flu arrows lately?)

**D) FLETCH CLEARENCE:** Certainly a top concern during bow tuning is fletching contact with the arrow rest. Any contact the fletching might have during the beginning of its flight will disturb the normal bending and recovery of the arrow down range. Spraying white foot-powder on the fletched end is a good method for uncovering this contact or uncovering unequal contact in the case of "surround" type rests. Then make adjustments to the rest, nock rotation, nocking point location, etc., to eliminate the contact.

## NOCK CONSIDERATIONS:

The nock on the back end of the shaft adds weight and it also grips the string with some degree of tightness. Both of these affect the flight of the arrow during its initial bending and recovery.

There are other factors like nocking point location and release aid attachment method.

**A) NOCK WEIGHT:** The Bohning Signature nock weighs 12.5 grains and the smaller "G" style nock with bushing weighs 12.6 grains. Combine this with three 4-inch vanes and you have a total add-on weight of 35 to 40 grains. This weight at the rear of the shaft will reduce the amount of shaft bending when the bowstring applies a force to that end. But it's all necessary to stabilize the arrow during flight and to secure it to the string during the power stroke.

**B) NOCK FIT:** How the nock fits to the bowstring is important in that a force is necessary to make it separate from the string during the power stroke. If the nock fits too tightly then more force is required to separate it and

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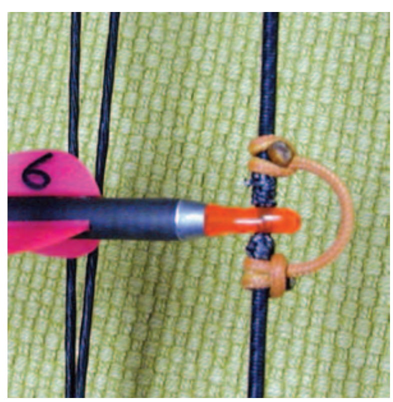

***How tight the nock fits affects how it separates from the string. Usually a tight-fitting nock makes the shaft act stiffer than a loose fitting nock. The D-loop arrangement affects how high or low the nock separates from the string and travels across the rest. Getting this "fit" to be consistent is important to tuning.***

 

# Product Directory

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*I prefer to do my preliminary testing with any new shaft size by installing screw-in inserts and using a variety of field points. Testing point weights from 50-grains up to 125-grains will give you sound information about how the complete arrow will bend over a distance of 40 or more yards. After this initial testing with six arrows I can make a better decision about installing specific weight glue-in points.*

the nock-end's direction and bending is affected. Too loose and the separation is inconsistent at best. A "snap" onto the bowstring is desired but the nock-tabs should return to their natural spread when the nock is on the bowstring.

**C) NOCKING POINT LOCATION:** If the arrow crosses the arrow rest with undue contact then shaft bending can be affected. The same is true if the arrow crosses the rest without contact as it does with the drop-away rests. Getting it just right so it's consistent is always the challenge. The basic rule I follow is to have the bottom of the shaft level with or slightly higher than the contact point on the arrow rest.

**D) RELEASE HOOK-UP:** How the release aid interfaces with the bowstring is important to how the string applies force to the arrow. Release jaws that contact the nock will cause a different shaft bending than when a D-loop is used or if the loop is attached to the release aid. I can think of seven different ways to hook the release aid to the bowstring so testing them all to find the most consistent for a given bow setup can get time consuming. You probably have a favorite that's most consistent for the majority of the bows you deal with but another method may work better – testing will tell.

## POINT CONSIDERATIONS:

For an arrow to do its job effectively it must have a point. Several factors now come into play when the point is added, most notably are weight, shape and how they affect balance point.

**A) POINT WEIGHT:** Adding a point to the front of an arrow shaft moves its center of mass forward. The heavier the point the more the center of mass is moved forward and the more the shaft will bend when a force is applied to the nock at the opposite end. The tricky part is getting just the right amount of point weight to aid the arrow in its flight to the target. Too light and the arrow will fly erratically and group poorly. Too heavy and the arrow falls from the sky too quickly. Lots of archers are concerned about the Front-of Center location of the arrow's balance point but I don't ever measure that, I shoot for groups since that's what builds high scores and brings home the bacon during hunting season. Testing field points across the range from 50 grains to 125 grains or more is the surest method to find the best-grouping arrow balance.

**B) POINT STYLE:** The shape of the point added has an effect on how the arrow flies and balances. The broadhead, for instance, extends the point weight more forward than the field point or target point and, therefore, moves the arrow's balance point more to the front.

Exposed broadhead blades affect the aerodynamics of the shaft flight and its bending recovery. For that reason bowhunters have to group-test their broadheads, even the mechanicals with enclosed blades. Any change in the point configuration and the arrow will fly, bend and impact differently because both its center of mass or balance point and its aerodynamics have changed. Most bowhunters skip over this detail thinking that the broadheads (of any kind) will impact the same as their field point arrows and, of course, they may get a big surprise from the tree stand. **Archers of all kinds must practice with the exact setup they intend to use for a given endeavor to be sure it shoots as expected.** That's a good reason to sell foam targets when you sell broadheads. If you have shooting lanes it may make sense to wall off



 Circle 38 on Response Card

***The shaft "rides" on the rest for some distance and is affected by the rest. In the case of the drop-away rest that distance may only be 2 inches but that's the most critical part since the shaft is undergoing its first bend then. Getting a consistent match between the shaft and rest is another critical element of tuning arrow groups.***

one lane for broadhead use and charge accordingly.

## ARROW REST CONSIDERATIONS:

The arrow touches the arrow rest for some amount of time during its forward flight. This is true for every arrow rest except the Air Rest that suspends the arrow in a magnetic field prior to launch. For all other rests the arrow shaft touches them during its forward flight and that means they affect arrow bending and recovery. This makes arrow rests a rather important part of the dynamic spine equation.

The "Drop Away" rests cradle the shaft for only the first 2 or 3 inches of flight. Remember, however, that the arrow shaft is bending during this time and is affected by its interaction with the rest and, so, you have to tune this interaction.

The fixed rests may sustain longer contact with the shaft and endure more of its bending and, therefore, the flexibility of its parts must be tuned to interact favorably with the shaft's flight. Launchers with differing spring rates must be tried, center-shot location must be shifted, surround type rests must be positioned and angled for best passage characteristics and the nocking point height must be adjusted. You may need to do all that, and more, in an effort to synchronize the rest parts with the bending and recovery of the arrow shaft.

## CAM CONSIDERATIONS:

The cams on your bow have an effect on the launch of the arrow and, therefore, on its bending. The more radical the cam design and its force-draw curve the more potential there is for radical shaft bending, although in the past few years manufacturers have been tempering some of their designs to provide a little softer feel.

Cams that have a sudden drop off in draw weight in the last 2 inches of their draw stroke will, on the power stroke, apply most of the forward thrusting power to the arrow in the same short 2 inches (In high speed video this acceleration is timed under .015 seconds). Matching the shaft's dynamic spine to this situation is tricky because the quicker the force is applied the stiffer the arrow acts. Consider the hammer hitting a very soft nail and applying a great force in a few milliseconds. The nail doesn't bend under the force because of the short time frame in which the force was applied and in the case of some cams most of this force is being applied in under .005 seconds.

Sometimes we can't tell whether the shaft is too weak or too stiff so we have only one method for dealing with the cams and that is to shoot-test with different point weights. We can only respond to the data we can collect and that's the arrow groups in the target. We may use the charts first to guide us in selecting three or four shafts that "should" work well.

Hybrid (asymmetric) cam timing and single cam rotational positioning are also factors in energy delivery. The mechanical parts must operate in a synchronized manner to provide a smooth and efficient delivery of the energy available. If they don't then arrow bending is affected and may be inconsistent from shot to shot. It is to the archer's advantage to have his bow's cam system operating in-synch and as a dealer this falls into your lap – at least when the bow is new – so you should have a good winch rig on which to check cam timing and position on every bow you sell.

## TUNING CONSIDERATIONS:

As it always does, this topic begins with the basics of draw length adjustment, wheel timing, nock fit, paper

***With so many shafts available you, as a dealer, will have to guide most of your customers to two or three shafts that will closely match their setup. Here, Steve Yoder at Lancaster Archery is selecting a particular ACE shaft to fill an order. When a customer is spending high dollars for arrows you'd better get it right.***

and powder testing. Oh yeah, you have to help your customers with their shooting form basics as well because you can't get reliable results at the target if the "launching" isn't consistent (I could write a book on this part!).

Here's the step-by-step procedure that leads to arrow shaft tuning:

1) *Set draw length.*
2) *Adjust cam timing and/or rotational position.*
3) *Set nocking point.*
4) *Check nock-fit and correct.*
5) *Install release loop.*
6) *Adjust arrow rest center-shot location.*
7) *Powder & paper test.*
8) *Sight setting at 20 yards, then 40 yards.*
9) *Group testing at 40 yards then 60 yards.*
10) *Redo powder test to be certain of clearance.*

Now I'm ready to test different point weights in the arrows I'm shooting. For hunting and target I use field points from 50 to 125 grains. Don't forget to add the 12 grains for the threaded insert to get an accurate total if you intend to eventually install target points.

I shoot test them all with six-arrow groups from 40 and 60 yards and shoot them through paper for a little more info. Usually one or two of these will group better and that tells me the broadhead weight and/or what weight target point I need. If several point-weights work well then you'll have to make a personal decision as to which weight to use – most stay light if they're shooting target or 3-D. Regardless, you should choose based on groups first, light-weight second.

If none of the points group to your satisfaction then perhaps your choice of static shaft spine is not correct. Choose another shaft that is slightly stiffer and repeat the process and if that doesn't work try a shaft that is slightly weaker. The results in the target will let you know when you're right.

## CONCLUSIONS:

Group tuning is never an exact science and depends on the shooting skill of the archer. Understanding that, you as a shop owner have to use your own best judgment to guide most archers to a reasonable arrow and point selection. Keeping your eyes and ears open to the better shooters in your area can give you good information as to what combinations work well.

In any event, you have to deal with dynamic arrow spine through observation of results in the target. The charts are great for guiding you to several shaft spines but ultimately you have to deal with real-world results so understanding a little more about what affects an arrow in flight is helpful. I hope the above information is helpful to your ability to get better groups.

Keep well, shoot straight. *Larry*

***Editor's Note:*** Larry Wise's first book, "Tuning Your Compound Bow," has been updated with a new chapter on hybrid cams plus other new information. His latest, "Core Archery" details correct form in a step-by-step format, defines back tension and how to execute it, and presents a plan for the high performance mental game. Get either though his web site www.larrywise.com, or by phone at 1-877-Go4-XXXs. They are also available from Target Communications, 7626 W. Donges Bay Road, Mequon, WI 53079.



***Getting long-distance groups like this in two or more consecutive ends (one end can be luck) takes a complete arrow package and good shooting form. The two most important aspects of the arrow are the D-loop/nock fit and point weight. First, your arrow must separate from the energy-imparting string consistently. Secondly, it must undergo an optimum amount of bending (and recovery) affected primarily by the point weight.***