Rick McKinney

On Arrows

As more and more companies are attempting to build arrow shafts it gets more and more confusing as to what makes a good arrow. Since most companies do not actually build their own arrows and others who are building arrows are not archers of any length of experience, it becomes more and more critical to explain the mechanics of an arrow and why it is important to choose arrows that are truly the quality you should expect.

There are three specific areas that determine a good arrow: weight, spine, and straightness. These three aspects are discussed by many, but it appears that they are a little misunderstood. Let's dissect each one and determine what makes them critical to good performance. Obviously, we could go further in talking about other reasons for good arrows such as surface finish, durability, and ease of use (e.g. bonding adhesion and pulling out of targets), but we will stick with the areas that may be difficult to assess without proper equipment.

Weight

Since weight is the easiest measure for most consumers to determine accuracy of an arrow, companies focus their attention on it. Let's face it, anyone can purchase a simple grain scale and then check out the weight of each arrow. However, the weight of an arrow shaft only gives you a hazy picture, at best, when you have to add glues, vanes, nocks and points/broadheads. How many people weigh their broadheads? When you switch broadheads, do you really think they are exactly the same weight? However, the weight of the arrow shaft is supposed to be critical? To a point, yes, but if you learn to weigh the broadhead or points and the complete arrow with vanes, nocks and inserts installed, you can get a dozen arrows close to two grains apart with no trouble at all.

But, I am getting ahead of myself. First let's determine how much weight deviation affects the impact point of arrows. About 15 years ago, I ran several tests to see how much can you be "off" in weight and still impact the same at 90 meters (approximately 99 yards). Since 25% of your performance was determined at 90 meters in the Olympics, it was a critical part of the game. It was determined that with a recurve bow, shooting fingers, and with an arrow speed of 200 feet per second, 1 grain of weight difference gave you an estimated 1 inch (2.5 cm) difference at 90 meters. Now this is with some extremely accurate people. Let's try to put that into today's equipment. With average compound bows giving you 250 feet per second (fps) arrow speeds, or more, the drop is less. Also, using a release aid gives you more consistency in speed as well. Thus, it is estimated that the drop is about 0.5 inches at 90 meters! The next step is to consider the average shot made for hunting. This is a bit under 20 yards for most!.This would mean that a one grain difference would cause the arrow to deviate at most 0.1

inches. This does not include gravitational pull, air resistance nor aiming capabilities which when added all together are 10 times greater at 90 meters!

Working with scientists at the Olympic Training Center in Colorado Springs at that same time we determined that one millimeter of movement of your sight pin gave you a one inch deviation at 90 meters as well. How many people can hold a bow without moving it 1 millimeter? Only a machine can do that! And yet, some people are claiming that a one-grain weight difference of an arrow can cause many problems-only psychologically, if you believe them! Jay Barrs captured the silver medal at the first World Indoor Championships with total arrow weight deviations of 9 grains! He kept his arrows consistently within a one-inch diameter circle for over 120 arrows. Let's see, he was using a bow that was giving him a speed of less than 200 feet per second, a recurve, with fingers at near 18 meters (19.5 yards). Oh, by the way, the guy who beat him was the next Olympic Gold Medalist, Sebastian Flute.

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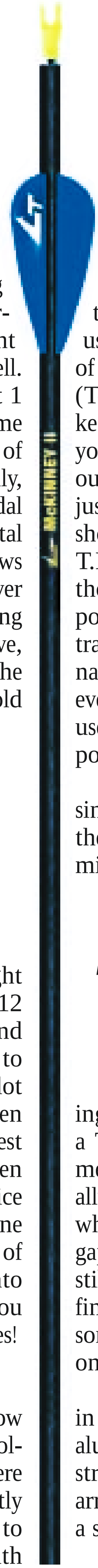
A simple test to evaluate the effect of arrow weight is to take the heaviest and lightest arrow in a group of 12 arrows. Without knowing which is the heaviest and which is the lightest, mark them as 1 and 2. Then go to 20 yards or even 50 if you want to and shoot them. Plot their impacts and do this about 5 or more times. Then go weigh them to determine which one is the heaviest and which is the lightest. Usually, if the arrows are even 7 or 8 grains different, you will probably not notice much impact difference at 50 yards, unless you are one of the top 50 archers in the world. Thus, the gimmick of weight deviation is just that, a gimmick to scare you into believing weight has a huge difference on impact. You can't aim well enough to discern the weight differences!



Straightness

The second most highly talked about aspect of arrow shafts that many manufacturers push is straightness tolerances. It's funny that several years ago, when there were no carbon arrows, arrow straightness was constantly being drilled into our heads-how important it was to have very, very straight arrows. This may be true with aluminum and aluminum and carbon mixed arrows, but when it comes to all-carbon arrows it is not as factual. In the late 1980s AFC and I ran tests to determine how straight an arrow needs to be in order to carry a 3 inch group at 50 meters (55 yards). We used a recurve bow, finger release, with an arrow speed of near 200 feet per second. We found that 0.010″ T.I.R. (Total Indicator Reading) was the maximum in order to keep a three inch group at this distance. Although were you to hand spin a 0.010″ T.I.R. arrow you would freak out, it proved to me that the impact point is the key, not just physical observation of the arrows. Thus, if you shoot an arrow of ±0.005″, you actually have a 0.010″ T.I.R. and it will group exceptionally well. However, those 50 top archers of the world will argue on this point, and rightly so. They are the "eight hours per day training" athletes who demand accuracy of the highest nature. Yet, over 90% of the archery population will not even notice this deviation—I should say that they may use it as it really is, an excuse, and not a real reason for poor performance!

There are many ways to determine straightness and since there is no agreed-upon standard for testing this in the industry, it makes it very difficult for you to determine what companies are really saying in their advertising. Most give you a number but may not state that it is a T.I.R. If you see a plus or minus type statement, it means that it is half of the T.I.R. Thus a ±0.003″ is actually a 0.006″ T.I.R. Now, you really need to know at what distance they measure this reading. Some use a 14″ gap when taking the reading while others use 28″, and still others anything in between, thus again you need to find out just what they are really stating. Straightness has some effect on shooting performance but not as much as one would think.

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The question still comes up about why straightness in a carbon shaft is not as critical as straightness in an aluminum shaft. Let's look and see why aluminum straightness is so important. Most of you are aware that arrows vibrate when they are launched. When you have a straight arrow, the frequency of that oscillation is fair-

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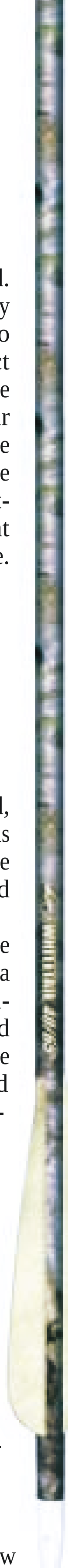
ly consistent and the impact points are very good. However, when the arrow becomes bent, the frequency of the arrow changes, thus causing the oscillation to change as well. This causes bent arrows to not impact in the same place as straight arrows. Arrows that are bent and straightened are affected, too. Look at your knuckles. There is extra skin on top and creases on the bottom. This is because when your fingers are bent the skin has to stretch at the top and compress at the bottom. An aluminum arrow, when bent, is stretched at the top of the bend and is therefore thinner there.

"Spine is probably the most important part of the arrow shaft . . . and the most ignored."

When the arrow is straightened, it is bent backward, stretching the other side. Thus the "repaired" bend is not quite the same thickness and does not oscillate the same as the rest of the shaft. Shafts repeatedly bent and straightened will be of less spine than the new shaft.

The all-carbon arrow cannot be bent. It can be bowed but not bent. A straight all-carbon arrow and a bowed all-carbon arrow have the same launch frequency. Thus, the frequency harmonics do not change and the impact of the arrow does not change. Now, can we say if an aluminum arrow is slightly bowed, it would have the same frequency as a straight one? Yes. However, bows very seldom occur in an aluminum arrow. You may have heard some people commenting that depending on where the arrow is bent it still may fly into the group. Generally this is a "bowed" aluminum arrow.

Does an aluminum/carbon arrow have the same characteristics as an all-carbon or a 100% aluminum arrow? It has more qualities in common with the aluminum arrow. Thus, keep an eye on those aluminums. You can straighten all-aluminum arrows, but it is almost impossible to straighten a carbon/aluminum arrow, at least by the average person.



Spine

Spine is probably the most important part of the arrow shaft . . . and the most ignored. I presume the main reason for this is because it is the hardest for a manufacturer to get right and keep consistent. Also, it is one aspect that cannot be measured very easily by the average person. Let's determine what spine is and not confuse it with spline! Spline is what the fishing industry uses in order to get sort of the "back bone" of the fishing rod. This is sort of an overlap of material in order to get a stiffer side to the rod. Keeping this stiff side on the upper side of the rod makes it easier to handle when reeling in that big one! In archery you do not want a spline! You want an even, consistent spine all the way around the shaft (circumferentially). Spine was established in modern times by Easton who uses a 29″ test shaft. You place this shaft on two posts measured out 28″ apart. You then place a 1.94 pound weight in the middle of the shaft and measure how far the arrow shaft drops down. This gives you a measure called a static (non-moving) spine. Typically at 0.400″ deflection is a 400 spine, a 0.600″ deflection is a 600 spine, and so forth.

When an arrow is launched from a bow, the arrow flexes and oscillates (controlled by what is called the dynamic spine). This flex needs to be a specific amount and stay consistent among all the arrows in order to carry a group. If the arrow flexes too much it becomes exceptionally critical. The smallest mistake made by the archer increases substantially if the arrow is too weak. If the arrow is too stiff it is not as critical, but does not give the best possible grouping. Thus it is far better for the arrow to be too stiff than too weak. This is why you may note that some companies fudge on the size arrow recommended towards the stiff side. This is far better than being on the weak side. Since the arrow flexes upon being launched, you would want it to flex the same. If the arrow is too stiff, it will favor the left side while if the arrow is a bit weak, it favors the right side. Thus you will get lots of rights and lefts if you have lots of inconsistent spines in your arrows. And that is exactly what you will get with many of the arrows on the market today. Since most archers do not know how to measure spine, they are unaware of why they are not grouping so well. Also, you may have noted that most arrows that are sold in groups of a dozen, only 6 to 8 arrows will group and the rest will not. Again, this is due to spine inconsistencies more than anything else. Sometimes you can get a few more arrows

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to group by moving the nock around the shaft a little in order to find a spine to better match the rest of the group.

Many companies do not keep very tight tolerances on spine consistency. This causes all types of problems for archers and for dealers. Of course, since most archers are not very good or accurate, they do not realize that the arrow is making them look even worse than what they really are. According to tests that I have been involved with, the tighter the spine tolerances, the more accurate the arrows become. Keeping them 0.005˝ plus or minus range in deflection (if the spine for a set of arrows was, 400 for a deflection on the spine tester of 0.400˝, the range would be from 0.395˝ to 0.405˝) is what was set years ago with aluminum arrows, whose accuracy has been proven over the years. Yet, some companies have spine deviations of over 0.040˝ plus or minus! Thus, it would be like putting spines of 2113, 2116 and 2119 aluminum arrows all in one set and expecting them to group well. It will not happen, obviously.

Part of the reason for having so many spine inconsistencies is due to the materials used. Some companies look for the cheapest product they can find in order to keep costs down. This causes huge spine deviations. Also, how the arrow is manufactured will cause spine inconsistencies. Most companies put the spine determining material on the outside and then grind it down to get as close to the weight they can get. However, this causes spine inconsistencies and breaks down the fibers that actually determine the spine. Cutting the materials requires tremendous precision in order to get the exact spines and many companies use something like a paper cutting device to get their patterns. This creates a great deal of spine inconsistencies as well. It also gives them a "spline" as talked about above.

All Together Now

Now, if you consider the inconsistencies in spine, straightness, and weight, you can see why there is so many discrepancies between arrow shafts. The degree of importance of these three aspects is determined by what material is used to make the shaft. With aluminum arrows, the degree of importance is straightness, spine, and then weight. With all-carbon arrows it is spine, straightness, and then weight. The spine of an aluminum arrow is normally very good to start with. However, this spine breaks down over time (as described above). Depending on the wall thickness, spines of an aluminum arrow can break down as fast as ten shots! This has been proven time and again by some of the best archers world wide. Although the only American manufacturer of aluminum shafts disputes this, the "proof is in the pudding." Top archers will replace these arrows very quickly without anyone knowing any different. Most all-carbon arrows start to lose their spine over several hundred shots due to wear. As the arrow penetrates the target, the friction microscopically wears down the outer layer of carbon and since most companies have their spine determining layer on the outside, the spine gets weaker and weaker over time. The aluminum arrow breaks down for different reasons. The flexing of the shaft upon impact of the target, pulling the arrow out of the target and the launching of the arrow from the bow continues to flex the aluminum tube constantly and we all know what happens to metals when continuously flexing them back and forth.

Now you can understand some of the simple physics of what happens to arrows and why it is important to examine them carefully in order to choose wisely when purchasing arrows.

Rick McKinney *is one of the world's most decorated archers. He was born in Muncie, Indiana where his father was a professional archer and managed a pro shop. His mother and brothers were also archers. Rick won the 1977, 1983, and 1985 World Championships. He won the U.S. National Target Championships nine times, Field Championships six times, Indoor Championships three times and Collegiate National Championships seven times. He has two Olympic Silver medals, 1984 (Individual) and 1988 (Team). His best score is 1352. Rick is currently President of Carbon Tech, a manufacturer of arrows, in Sacramento, California.*