2010 Compound Hunting Bow Evaluation

By *Anthony Barnum*

Overview:

The focus of this evaluation is Compound Bows that highlight the cutting edge of those products currently available in the archery marketplace. The goal is to provide those archers who enjoy hunting with appropriate objective information, as well as some subjective commentary, for aiding in the purchasing process. That being said, this evaluation is by no means conclusive; some tests could not be performed due to limitations in resources, time, or budget. Each archer should assess what is important to him or her and interpret the results accordingly. As always, it is a good idea for anyone who is in the market for a compound bow to shoot as many different makes / models as possible to determine what best suits their individual needs and desires.

The format of this year's evaluation is very similar to 2009, with the only differences being some changes in the test equipment used to conduct the test as well as the inclusion of an additional Bow Segment: Target Models.

Bow Segment	Guidelines	Draw Length	Draw Weight
Flagship Model	Bow that manufacturer feels is the "flagship" of their lineup; generally the most "marketed" bow	**29 – 29 ¼ in.***	**60 ± 0.1 lb. peak**
Short-Draw Model	Bow designed specifically for women, youth or short-draw archers; generally has maximum draw length of 27"	**26 – 26 ¼ in.***	**50 ± 0.1 lb. peak**
Speed Bow Model	Bow that is designed to provide as much speed and raw power as possible; generally the fastest bow of the lineup	**30 – 30 ¼ in.***	**70 ± 0.1 lb. peak**
Target Model	Bow designed for those archers who participate in target shooting; generally a longer axle-to-axle, larger brace height bow.	**29 – 29 ¼ in.***	**60 ± 0.1 lb. peak**

*** See Figure 1 below for Draw Length measurement guidance: True Draw Length + 1 ¾"; Tolerance (+0.25 in. -0.00 in.)**

Initial Conditions and Test Categories:

Each participating manufacturer was asked to provide the compound bow that they felt best represented their company and would best suit the following categories:

- **Speed per Inch of Power Stroke**
- **Vibration**
- **Efficiency**
- **Noise Output**

Note: The criteria outlined in this evaluation were deemed to be the important factors to consider for a compound bow. This evaluation in no way represents all areas that are important to archers. Personal experience and preference were used to derive these criteria.

The requested draw weight / length is as specified in the table above; upon receiving each bow, a thorough examination is conducted straight out of the box. Notes are taken documenting any imperfections in the finish and machine work in the following areas:

- **Grip**
- **Cable Guard**
- **Riser**
- **Limbs / Pockets**
- **Cams**
- **Strings / Cables**

After the inspection is complete, a Revere Model 9363 load cell and TotalComp T500E indicator, adapted for use on a Hooter Shooter, are used to determine the peak draw weight, draw length (see Figure 1 below), Actual Let-Off and Effective Let-Off; brace height is measured to the nearest thousandth of an inch with a set of Mitutoyo Calipers while axle-to-axle length is measured with a calibrated 36" steel rule.

Next, a New Archery Products QuikTune 3000 arrow rest and a brass nock are installed and each bow is shot by hand in the "out of box configuration" to baseline the speed of each bow as provided by the manufacturer. Again, notes are taken to document the feel of the grip, the draw cycle, and the sound & vibration output, as felt by the shooter, to prevent any bias in the subjective commentary that may result from reviewing the objective test results later in the evaluation. After this assessment is made, tuning to Draw Length / Draw Weight specifications is made as follows:

- Draw length is adjusted with modules or integral draw-stops (as applicable).
    - Modification to strings / cables is only used as a last resort with permission from the manufacturer so as to minimize impact to efficiency
- Draw weight is adjusted through modification of the limb bolts
    - If the specified draw weight can't be reached by the particular bow (i.e. draw weight is too low), modification to the string / cable(s) may be necessary

Note: A tolerance was placed on both draw weight and draw length specifications as industry standards on how to measure these two items are ambiguous at best. For bows that are within these specifications straight out of the box, no modifications are made. Where modifications are necessary to bring at least one of these parameters into specifications, it is recommended that both be corrected and set exactly as defined.

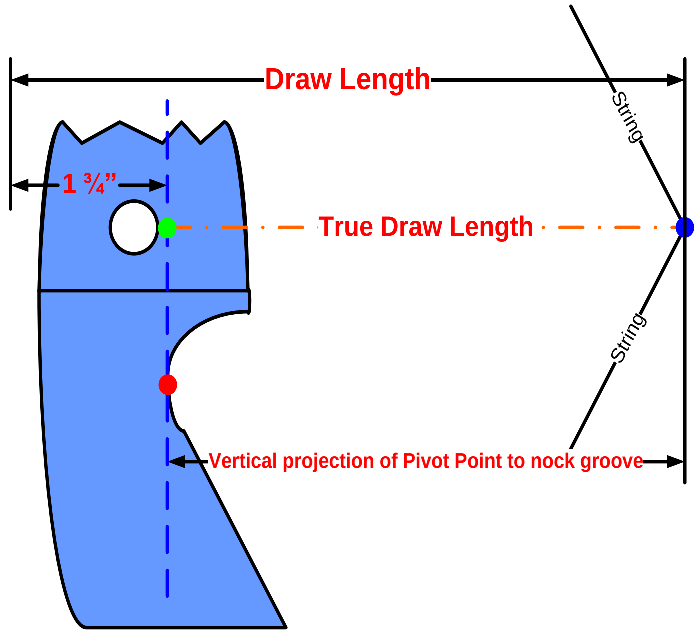

Figure 1 Draw Length Measurement Guide

All modifications requiring a bow press are made with a Last Chance Archery Power press. This press uses an electric motor and screw-drive mechanism to apply pressure to the limb tips of each bow, reducing the amount of stress put on both the limbs and riser.

Draw-Force curves are then created to determine the amount of stored energy for use in dynamic efficiency calculations, after which objective performance testing begins.

For the performance tests, 250 grain Easton Flatline 500 Arrows, 300 grain Easton FlatLine 400 Arrows, 350 and 360 grain Easton Flatline 340 Arrows, 400 and 420 grain Easton ST Epic N-Fused 400 Arrows, 450 grain Easton ST Epic Camo 300 arrows, 490 and 540 grain Easton AXIS FMJ 340 arrows are utilized. These arrow weights equate to 5, 6, 7, and 9 grains per pound of the specified peak draw weight for all test categories except 70#, where the 540 grain arrow is used in place of a 630 grain arrow. All arrow weights are verified using an Easton Advanced Grain Scale and confirmed with a Coffey Marketing US Reloader Digital Pocket Scale.

A Hooter Shooter is used throughout the performance testing to minimize human induced errors. The Easton Professional Chronograph is used for all speed measurements in conjunction with the Pro-Chrono Digital Chronograph from Competition Electronics for confirmation. The Easton Professional Chronograph was used primarily for its ability to display speeds down to the tenth of a foot per second. Both chronographs consistently provided speed measurement within 1-2 fps of one another.

Each bow is evaluated on the 4 objective criteria outlined below. In addition, this year's evaluation includes Noise Output / Vibration testing with 6 grain per pound arrows while each bow is equipped with a 12 inch, 14 ounce B-Stinger Pro Stabilizer. Where applicable, a decrease in Noise Output and Total Vibration is noted in the report.

Test Category	Assessment
Dynamic Efficiency	Provides an indication of the amount of energy output by a bow relative to the energy expended through drawing the bow back. An assessment is made with multiple arrow weights
Speed per inch of Power Stroke	Provides an indication of the amount of speed output by the bow over the distance from the valley to the static brace height position. An assessment is made with multiple arrow weights.
Noise Output	Provides an indication of the noise output characteristics of a bow at the "point blank" range utilizing a series of shots with multiple arrow weights.
Vibration	Provides an indication of the vibration characteristics of a bow during and after shot execution utilizing a series of shots with multiple arrow weights.

Dynamic Efficiency

Objective: The objective of the Dynamic Efficiency test is to provide an assessment of the amount of energy output by a bow relative to the amount of energy expended by drawing the bow back.

Rationale: The purpose of the compound bow is to transfer the energy expended in drawing the bow back (Potential or Stored Energy) into the energy propelling the arrow downrange (Kinetic Energy). Unfortunately, not all of the Potential Energy is turned into Kinetic Energy. There are various reasons for this, but regardless of the cause you are not getting all the energy out of the bow that you have put into it. The reason for testing dynamic efficiency is to determine which bows perform the best in transferring the energy that is "stored" into the energy in motion that is released through the arrow.

Procedure: A Revere Load-Cell, modified to mount on the Hooter Shooter, is used to create Force – Draw and Let Down curves for each bow. The plot information obtained from this setup is then analyzed to obtain the amount of energy expended in drawing the bow back (See "Stored Energy" in Figure 2 below). This value in pound-feet (lb-ft), considered "potential energy" (or stored energy) for this assessment, is then compared with the Kinetic Energy output by the bow during shot execution with 4 different arrow weights. The Kinetic Energy is calculated with the following formula:

$$\frac{ArrowWeight * Velocity^2}{450240}$$

Where "KE" is in pound-feet, "Arrow Weight" is in grains, "Velocity" is in feet per second (fps) and 450240 is a conversion factor that accounts for unit changes between arrow weight (grains) and velocity (fps). The ratio of the Kinetic Energy to the Potential Energy for all arrow weights is assessed.

Example: The speed of a 350 grain arrow out of the 70# PSE X-Force GX was measured to be 342.5 feet per second (fps). The speed of a 540 grain arrow out of the same bow was measured to be 278.6 fps. Using the formula for KE above, we can show that the Kinetic Energy of the 350 grain arrow is 91.2 lb-ft, while the Kinetic Energy of the 540 grain arrow is 93.1 lb-ft. Dividing these two KE values by the Potential Energy (105.7 lb-ft), a dynamic efficiency of 86.3% and 88.1% is achieved, respectively.

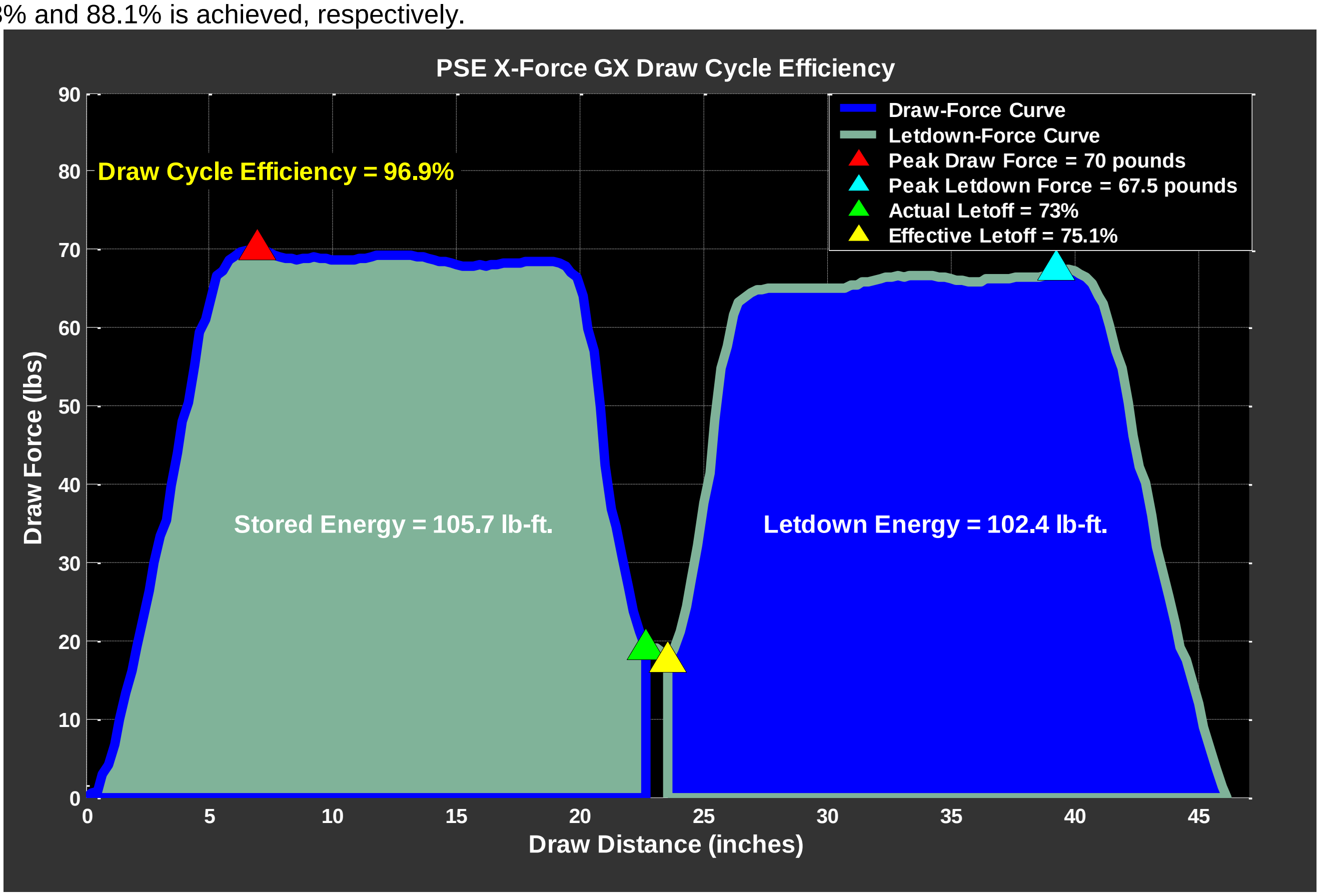

Figure 2 Force Draw Curve and Letdown Curve

Objective: The objective of this section is to determine the speed properties of a bow based on the length of its power stroke at point blank range with 4 different arrow weights.

Rationale: Because there are so many varying configurations in today's compound bows (e.g. low or high brace height, reflex / deflex riser geometry), the amount of speed output by each bow per the inch of its power stroke is a reasonable way to compare each bow on more of an equal playing field.

Procedure: Each bow is mounted to the Hooter Shooter. A series of 5 speed measurements are taken with an Easton Professional Chronograph at a distance of three (3) feet from the throat of the grip for each bow with 4 different arrow weights. These measurements are confirmed with a Competition Electronics Pro-Chrono Chronograph, with the highest and lowest readings removed before averaging the speed per arrow weight. The brace height of each bow is then measured and 1 ¾ inches is added to this measurement. This value is subtracted from the measured draw-length (all bows setup to 29" + ¼", -0" draw-length) to determine the length of the power stroke. The power stroke value is then divided into the average speed for each of the arrow weights. The average speed per inch of power stroke over all arrow weights is then calculated for use in the overall results.

Assumptions: An assumption is made that the speed per inch of power stroke more accurately characterizes the speed performance of a given bow than just comparing raw speed of each bow without consideration for its configuration. Another assumption is made that the string travel past the brace position during shot execution does not impart any energy on the arrow.

Speed per inch of Power Stroke

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Noise Output

Objective: The objective of this section is to determine the noise output properties for each bow at point blank range.

Rationale: A great deal of emphasis is placed on the amount of noise output by compound bows. Today's hunting bows have different noise output characteristics with varying arrow weights. Many hunters use heavier arrows for increased down range kinetic energy, while others use lighter arrows for increased speed. Because of these issues, noise output readings are measured at point blank range for 4 different arrow weights.

Procedure: Each bow is mounted to the Hooter Shooter, after which a PCB Piezotronics microphone is setup at a distance of 36 inches from the throat of the grip of the bow. The Microphone is set at a height of 36 inches, and is offset from the path of the arrow by 6 inches. A series of five (5) shots is executed for 4 different arrow weights from each bow, during which sound output data is captured. This data is then analyzed, after which the highest and lowest readings are removed; the average noise output is calculated for each bow for dB, dBA and dBC weightings.

Assumptions: An assumption associated with this test is that the sample size of three firings per arrow weight is sufficient to correctly characterize the noise output of the bow at point blank range.

Equipment Used: National Instruments USB Data Acquisition unit, PCB piezo-electric microphone, Matlab software.

Test Setup: Microphone mounted 36 inches in front of bow at a height of 36 inches, with an offset of 6 inches from the centerline, as shown in Figure 3.

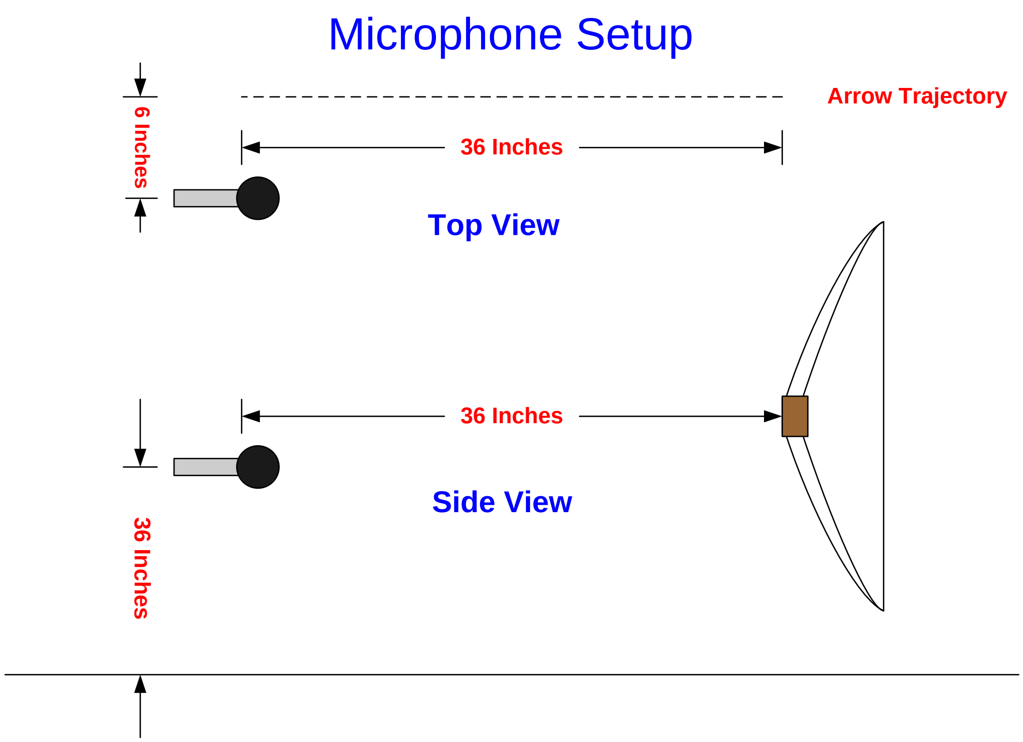

Figure 3 Microphone Setup

Vibration

Objective: The objective of the Vibration Test is to provide an indication of the peak vibration each bow produces under shot execution with four different arrow weights. To most accurately reflect the vibration felt by an archer, the vibration data is collected on the front of the bow's riser opposite the throat of the grip.

Rationale: The less vibration output by a bow and felt by the archer during and after shot execution, the more enjoyable a bow is to shoot, especially during long practice sessions. Our test equipment is highly sensitive; an archer may not be able to distinguish between some of the measured vibration outputs of given bows.

Procedure: A PCB Piezotronics tri-axial accelerometer is attached to each bow on the front of the riser at a point opposite the throat of the grip. A series of 5 shots is taken with 4 different arrow weights, during which vibration data is collected. After data collection is completed, each raw data set is analyzed to determine the maximum Total vibration amplitudes (combination of X, Y, and Z vibration amplitudes; see Figure 4 below). The highest and lowest measurements are removed, after which the average maximum vibration amplitude of the three remaining shots for each arrow weight is calculated.

Assumptions: An assumption is made that the front of the riser of each bow, opposite the throat of the grip is an area that is representative of the amount of vibration an archer can expect to experience.

Equipment Used: National Instruments USB Data Acquisition unit, PCB tri-axial accelerometer, Matlab software

Test Setup: Accelerometer mounted opposite the throat of the grip on the front of the riser, with orientation as shown in Figure 4.

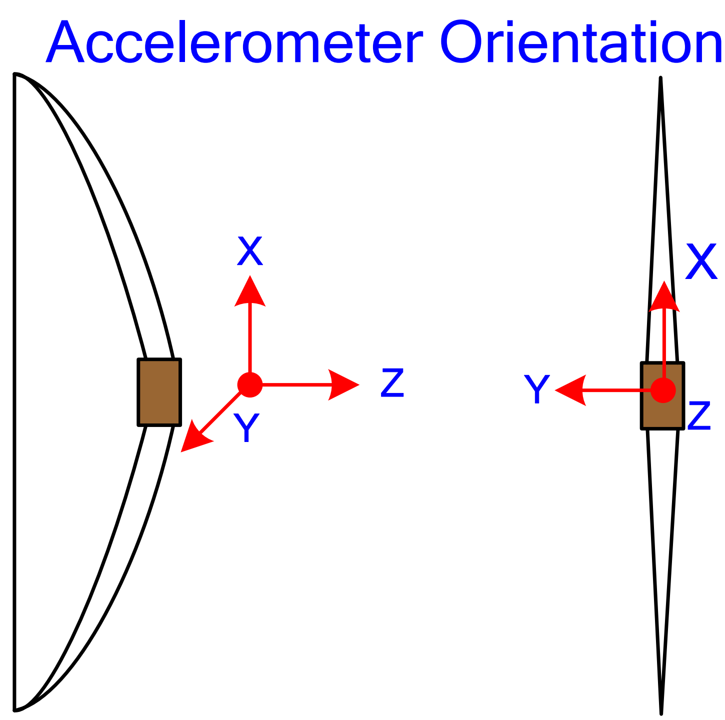

Figure 4 Accelerometer Orientation

Sponsors

We would like to thank the manufacturers and sponsors who provided equipment for this evaluation; without them and their support, this evaluation never would have been possible.

Blair Sandberg from The Stabilizer Company provided a 12 inch B-Stinger Pro stabilizer with a 14 ounce weight for use in the noise output and vibration testing. This adds an element of realism to the testing as many folks add accessories to help dampen vibration and minimize noise output. Blair's insight and knowledge of stabilization is unparalleled in the industry and he is a great guy to work with.

A big thank you goes out to Easton arrows and, more specifically, Rich Packer. Easton provided all of the arrows used for this evaluation and Rich worked hard to provide combinations of points, inserts, nocks, and shafts that met my very specific needs. I was extremely impressed by the quality and consistency of the Easton arrows and would recommend them to anyone.

Mallory Swaney of Last Chance Archery provided the Power Press Deluxe, which uses an electric motor mated to a screw drive mechanism to compress the limb tips of just about any bow on the market. This has the effect of minimizing stress on both the riser and the limbs. This press is very easy to use and was extremely helpful in getting the bows fine tuned for the test

James and Barbara McGovern of Rinehart targets have supported these evaluations since I started them in 2006 by providing targets for use in the evaluation. They are both very easy to work with and their products are awesome. The new RhinoBlock and RhinoBrute were used throughout my testing for 2010. They are a bit larger than the versatile 18-1 targets that I've used in the past, and maintain the same great durability that the 18-1 targets are known to have.