AIRGUN BALLISTICS

Some preliminary remarks.

By Robert Beeman

19 Sept 2006

Velocity indeed is a key factor in airguns, perhaps even more so than in firearms. The higher the velocity is, the flatter is the trajectory of the pellet. Thus higher velocity means that we can be less concerned with the exact determination of range, as a faster pellet would be closer to the line of sight than a slower one. This is one of the key reasons that hunters of small game often select high velocity cartridges. It was realized that most shooters cannot accurately judge distance in the field, few of us can. With small targets, it is often more important to have a flat shooting gun, with which the shooter can more easily hit the small critical area of that target, than to have a projectile with greater energy. Higher velocity means a faster "lock time", or exit time, the amount of time that elapses between the actual trigger release and the projectile emerging from the muzzle. A faster exit time means that the flight line of the projectile will be closer to the shooter's intended sight line. The sight line is, of course always moving around as the shooter is aiming. Shorter lock time is of even greater importance to the new and poor shot than it is to a very highly trained shooter who can control the gun's movement to a greater degree after trigger release. Higher velocity means greater effective accuracy; this is of very special importance when one considers the extremely small critical areas of the kind of game and other targets fired upon by airgunners. We must be very careful not to confuse "effective accuracy", the only kind of accuracy that really counts in the field, with "theoretical or benchrest or machine rest" accuracy.

Higher velocity also can mean greater actual accuracy. While working on an airgun injury case, the Crosman Airgun Company and I conducted independent tests which revealed that a .177” (4.5 mm) caliber match air rifle became more and more accurate as its muzzle velocity was increased from 400 fps to 700 fps. The very top match air rifles fire a 177” (4.5 mm) pellet of about 8 grains at muzzle velocities of about 550-650 fps. It had long been felt that muzzle velocities in the 550 to 650 fps range resulted in the greatest air rifle accuracy. This conclusion was reached because most match airguns fired in this velocity range and they were the most accurate airguns in existence. While this may be the optimum velocity for some airguns, the selection of these velocities for indoor match shooting also may be a function of other factors such as custom and the ease of manufacturing, cocking, and shooting a gun of that velocity.

Inherent accuracy may or may not increase, as velocity is further increased over this indoor optimum, but, for airguns used outdoors, “effective accuracy” greatly increases. This is because, as velocity is increased, not only does the trajectory becomes flatter but side winds do not have as much time to affect the pellet’s path. Thus a higher velocity airgun makes it easier to place the pellet more precisely on the intended targets at varied, and generally unknown, distances. The drawbacks of lower velocity are not factors to paper target match shooters. They fire in windless, indoor ranges at exactly known distances.

The increase in actual effective accuracy, which can accompany higher velocity in outdoor airguns, perhaps is the primary reason why so many American gun makers have increased the velocity of airguns that are used outdoors.

To get some perspective on airgun velocities, consider the muzzle velocities of some well-known guns: A typical "BB" gun imparts about 250 to 350 fps to a light (about 5 grains [0.32 grams]}, .174” (4.4 mm) steel ball. A .22” (5.5 mm) rimfire cartridge rifle has a regular-speed muzzle velocity of about 1025 to 1145 fps. Ten pumps in a Daisy Powerline 880 or Crosman Powermaster 760 BB/pellet pneumatic will fire pellets at about 570 to 670 fps. Ten pumps in a Benjamin M342 .22 caliber air rifle, produces about 640 fps. Ten pumps gives about 605 fps in the .177” Crosman 1400 or 695 fps in the .20” Sheridan air rifle. The muzzle velocity of a Beeman R-1 air rifle ranges about 590 to over 1100 fps, depending on model and caliber. A .38" Special (9 mm) firearm or .45" (11.4 mm) ACP firearm wadcutter bullet moves at about 770 fps muzzle velocity, but is extremely dangerous due to its great weight. In terms of the more familiar miles per hour, the BB gun sends out its projectile at about 170 miles per hour, while a top level adult air rifle will rush its projectile out at over 750 miles per hour. Plaintiff lawyers in airgun cases often dwell on the velocity of airguns as a measure of their danger. However, one must temper any considerations of velocity with the mass of the moving object; obviously most of us would choose being hit with a BB at 170 miles per hour rather than by an automobile, or even a hard baseball, going “only” 60 miles per hour!

DEFINING AIRGUN POWER:

Although the muzzle velocity of airguns has been the primary yardstick by which adult airguns have been compared in the past, this figure does not have a lot of significance in the real world. To start with, it is velocity at the target, not at the muzzle, that really counts in field use of an airgun. The field shooter and hunter is most concerned with how hard his projectile hits the target, and that involves not only velocity but projectile weight, projectile shape, and numerous environmental factors. An airgun projectile ricocheting from a hard surface, or even touching a leaf or grass blade, may lose much of its power and accuracy.

Some individuals, notably those who feel more comfortable when the world is reduced to fewer and simpler considerations, like to say that muzzle energy is the only true measure of an airgun's output. While that might be considered true from a physicist's standpoint, because muzzle energy is a combined function of both projectile velocity and mass, it downplays some extremely important considerations, such as trajectory, wind deflection, penetration, expansion, wound channel size, and the very inertia of the projectile.

Nevertheless, muzzle energy is the most meaningful way to compare the power of airguns. Giving gun power in terms of energy is the most practical way to compare guns of different caliber and projectiles of considerably different weight. This is now necessary as the market has become more sophisticated and it is important in preventing unfair, unrealistic legal comparisons of airguns and firearms. Comparing guns by energy, generally muzzle energy, also better compares the true efficiency of various guns. A quick examination of the Beeman, and other top line airgun catalogs, shows that the more powerful spring piston air rifles are much more efficient in .25” caliber than in smaller bores. Some of the most powerful spring piston airguns, such as the Beeman Kodiak, generally are not even offered in .177” caliber because the powerful air flow of such guns literally is strangled by the small bore.

Airgun energy generally is expressed in foot pounds. It is well worth considering, in practical terms, what a foot pound represents. One foot pound is the energy that a one pound object releases when falling one foot (ignoring the friction of air, which, from a very rough practical sense over very short distances, we may do for very dense objects). Thus, one can roughly consider that a gun firing with a muzzle energy of 12 ft./lbs. is about the same as dropping a 16 oz. hammer head from about 12 feet. Extend that to a 30 ft. drop for a 30 ft./lb. gun. Imagine being hit by that falling hammer head and you are doing a very crude visualization of the gun’s potential hitting strength.

II. Penetration:

In European airgun factories, airguns commonly are tested by firing against a shielded hard steel "splash plate". If the pellet explodes into fragments the gun is considered to be in good condition. Note that a magnum spring-piston air rifle can continue to explode its pellets against a steel plate to over 35 yards!

Americans frequently test their airguns by firing into soft wood. Unfortunately wood probably is one of the worst possible testing materials because its grain, type, and condition varies tremendously with wood species, dryness, etc.. However, some very rough "ballpark" ideas of penetration can be had by this method. These notes refer to .177” caliber airguns. Guns firing at 630 fps will usually completely bury their pellet into soft pine or redwood. An 800 fps sporter will frequently tear completely through a 1” finished board, splintering out the rear as the pellet leaves! Aluminum beverage cans provide more uniform testing material, but maximum penetration depends on hitting them exactly square. A 640 fps match test air rifle could go right through six cans. A magnum sporter could rip through over 10 cans. Even a match air pistol could go completely through four!

Ballistic putty is one the best materials for testing airgun projectile penetration. It is relatively uniform and so dense that penetration depths can be rather easily measured from the surface. It is far denser than flesh. A soft lead, round nose pellet from a 780 fps gun will penetrate a total of about 3/4" into this material at room temperature at about one foot firing distance. (Don't forget to add the length of the projectile when measuring penetration depth!).

There are several other good materials that can be used for penetration testing. The outstanding airgun author Tom Holzel champions the use of Ivory soap bars. Most forensic and ballistic laboratories use various specialized media such as ordnance gelatin and ballistic clay. We will consider those materials in separate articles.

Penetration is not completely a function of velocity, of course. A hard, pointed pellet like the Sheridan or Prometheus has excellent penetration but has less shock power than a mushrooming soft lead pellet. A sharply pointed pellet, like the Silver Jet pellet, also penetrates deeply but its softness allows some expansion for shock value. The Crow Magnums hollow point maximizes expansion. A really hard projectile, such as a steel BB or dart, can have quite great penetration power, but its capacity for injury is greatly reduced by the low amount of tissue damage.

A very technical standpoint is appropriate when considering perforation or penetration in the forensics of human injuries with airguns. Technically speaking, the threshold levels for beginning penetration in human tissue are about $0.2 J/mm^2$ for bone, $0.1 J/mm^2$ for skin, and $0.06 J/mm^2$ for eyes.

Just as with high velocity firearms, over-penetration can be a problem with airguns. Some airgun projectiles may make a great impression by the number of telephone book pages they can penetrate, but the wound channel such pellets produce in the field may be so tiny as to have almost no knock-down effect. Unfortunately, the "acupuncture" effects of such projectiles and others, such as steel core pellets or darts, may mean more than just the loss of game to the shooter; they may mean a long, cruelly lingering death to an injured animal perhaps without the shooter even knowing that he scored a hit. Even pointed lead pellets may have undesirable over-penetration if used on very light game at close range. Such prey calls for the use of a hollow point pellet, or at least a flat head wadcutter pellet.

PELLET FLIGHT

The typical airgun projectile, with its characteristic diabolo (not diablo, that's Spanish for devil!) hour-glass shape, is basically different from that of most firearm projectiles and thus some information about bullet performance may not apply nearly so well, or at all, to pellet performance. At the present time very little empirical information on pellet performance has been published. Much of that which has been published may have very little to do with the most basic points of pellet performance. For instance, many airgun shooters become very concerned if one batch of pellets varies in weight from another. Such differences may simply require a slight change in sight adjustments. Of somewhat more importance is the matter of weight variation within a given batch of pellets, but the significance of even this absolutely pales in comparison to the importance of the evenness of weight distribution within each individual pellet. Pellets with quite a significant weight variation could be extremely accurate in test firing, especially at close ranges, before trajectory differences become pronounced, if the mass of each pellet is evenly distributed within the design of that pellet. However, perfection of weight distribution, especially within a series of randomly selected pellets, is virtually impossible, but such uniformity is one of the keynotes of pellet quality - and thus cost and performance. As in so many matters, there is no free lunch in the pellet business.

The displacement of weight from a perfect arrangement within the design of a given pellet has both radial and longitudinal components. Considering only the radial component, a perfectly balanced pellet would have the center of weight distribution at the axis of the pellet. Pellets in the real world virtually always have their weight center slightly off center from the axis. As the pellet moves up the rifle barrel and a spin is imparted to the projectile by the rifling, the centerpoint of weight is going to follow a helical path rather than the straight axial path that a pellet itself makes as it passes up a perfectly straight bore. In pellets of even only moderate quality, the diameter of this helical path certainly must be less than a thousandth of an inch. The pitch of the helix is going to be very long, matching the pitch of the rifling. Thus, if this helix should somehow magically become visible, it would certainly appear, except under extreme magnification, as a perfectly straight line.

Considering the above should not be difficult, but it requires a considerably greater stretch of the imagination to understand what must happen at the muzzle. A weight on a string swung around above ones head will follow a circular path. Consider that the pellet, with its off axial center of weight, is being spun around and around in the rifled bore but is restrained from flying to the side by the bore of the gun. Remember that because the projectile is swiftly moving forward, the path of the weight center follows not a circle, but an extremely elongated helix. When the spin of the weight center exits the muzzle it is going to cause the weight to fly off at a tangent from the spin, just as the weight on a string flies off at a tangent from the circle when the string is released. However, since the pellet's weight center has been traveling in a helix rather than a circle, it will fly off at a tangent from this helix. Depending on where it leaves the helix, this tangent might parallel the bore axis or point at some angle away from it, more likely away. However great or small the deviation of this tangent is from the axis of the pellet and the gun’s bore, two things must be kept in mind. First, since the tangent is flying off from a helix that has such a long pitch and such an extremely small radius, the helix would appear as a straight line if visible to the naked eye and the actual deviation from the axis is going to be extremely small. The deviation from the axial direction will be perhaps less than a millimeter to only a very few millimeters at a distance of ten meters from the muzzle. Second, we must not confuse this tangent of force with the actual path of the pellet. This tangent of force is simply an off center line of force attempting to push the comparatively large mass of the pellet off from the forward, axial path on which its forward inertia is taking it. However, we can see that a pellet with unevenly distributed weight, which is true to some degree of virtually any pellet, is going to start to tip, or "yaw", upon exit from the muzzle and it is going to be pushed further and further away from the axial path upon which inertia alone would take it. The uneven weight distribution thus has caused the pellet to start to tip at the muzzle and this tipping is going to become more and more pronounced, causing an ever increasing spiral of the flight path which will result in greater and greater deviation from the axial line of flight until a point of chaotic instability is reached. The pellet will then begin to tumble and become extremely inaccurate. Of course, the pellet is also subjected to force lines from the continual pull of gravity and from air movements caused by wind and heat waves. The above factors also probably are involved with the accuracy and point of impact changes that occur when a gun is tilted from the position in which it was sighted-in. If there is any damage, even very minor, at the muzzle or if the muzzle is cut even a microscopic amount off from square, the muzzle may impart a good deal of instability to the pellet. The last one millimeter of a barrel can have more effect on accuracy than the entire rest of the barrel!

For an diagrammatic view of pellet precession and nutation, click on

http://www.eatel.net/~amptech/elecdisc/nutation.swf

The "conventional wisdom" is that a small variation is going to have less effect on a large projectile than an equal variation in a smaller projectile. However, in the absence of experimental evidence to the contrary, I believe that an airgun pellet's shape might be a greater factor than its mass under many conditions, within the normal range and velocity of airgun pellets. The length of most larger bore pellets is shorter in relationship to their diameter than in smaller bore pellets. It is possible that this relatively greater length of smaller bore pellets results in them tipping less, having less yaw, due to the tangent of force which develops when unbalanced pellets emerge from the muzzle. Also, the greater relative length of tail on the smaller diameter pellets may give a relatively larger area for air pressure to force the gyrating pellet back onto course. Since the tail of a diabolo pellet has a shape much like the tail on a shuttlecock, a feature not shared with most firearm projectiles, there may be a significant contrast here with typical firearm projectile behavior. Most firearm projectiles simply do not have most of their mass in the forward end with a large, flared, stabilizing tail behind. Of course, a round ball, like a BB, or a lead ball, is not going to have yaw, or any functional result due to tipping, in the usual sense, as a sphere presents the same shape surface regardless of how its axis may tip. A very uniform ball may have quite excellent accuracy to a surprising distance because of this.

The commonly observed greater accuracy of smaller diameter pellets versus larger diameter pellets may also reflect a difference in manufacturing tolerance in some designs. Almost all the attention to producing highly accurate pellets has been focused on .177" caliber pellets. The tolerances and sorting of larger pellets usually has not been held to as rigid a standard. Also, the design and configuration of a pellet which is highly accurate in .177" caliber may simply not be as conducive to stability, especially without careful consideration of proportion, in larger diameter pellets. The manufacturing perspective and tolerance in making .177" caliber barrels versus larger bore barrels may be a major consideration in some cases. Further, when comparing airguns which are supposedly identical, except for caliber, one generally is comparing guns with the same outside barrel diameter. The smaller bore barrel has greater weight and stiffness and thus considerably less barrel oscillation during firing. This difference is not as pronounced when comparing firearms of larger bore diameters. Also, as is the case in so many considerations of airgun performance, minute differences of various factors, which might have a great effect on airgun performance, might simply be swamped by the relatively tremendous force and projectile mass of firearms. Thus differences which would favor the accuracy of smaller projectiles in airguns may have little or no significance in firearms. We are just starting to understand airgun ballistics, but it is clear that we cannot simply consider them as if they were small firearms. Many aspects of airgun ballistics will surely be shown to be partially or even fundamentally different.

Sometimes, experience reveals that theory springs from experience and not the other way around. After very extensive testing of Beeman and RWS magnum air rifles, the outstanding airgun author, Tom Holzel, found that .25" caliber clearly was the most accurate of the four calibers from .177" to .25".

Testing and Studying Airgun Ballistics: Airgun ballistics as a field is perhaps some decades behind firearm ballistics. Some would say that we are only now entering the 20th century. However, we have a tremendous advantage that the firearm testers did not have in 1900 or even very late in the century. We have some wonderful instruments and programs to speed the development of our field!

Once you have stepped up from using aluminum cans, Ivory soap, or ballistic putty you will need use of a chronograph. This simply is an instrument that measures the time a projectile takes to travel from one point (start screen) and another (closing screen). No longer do we have to put up with having to actually cut replaceable screens with our projectiles, now we can simply measure the tip between the shadow of a projectile passing one screen and the shadow of it passing the next screen or screens. Over the years, I have used the wonderful Oehler Chronographs, both in our airgunsmithing shop and in the field, and several other chronographs. I still recommend the Oehler machines as the very best, but the Oehler Personal Ballistic Laboratory Model 43, as their basic unit is called, now costs about $800. Check it out at www.oehler-research.com . For travel use and field studies, I have often used the Combro cb-625 Chronograph made in England (www.combro.co.uk) which not only is it very inexpensive, but it is so small that you can carry it in your vest pocket! It has two microscopic sensors which read projectile shadows from the sun or even a room light. It just straps onto the muzzle of the airgun to be tested by rubber bands. Although so very handy and so very portable, I often have a hard time getting it to consistently read out velocity figures - getting the pellet to be right on the very tiny, critical sensory path can e very tricky. However, I have used it in many unusual places to be testing firepower - like various law offices when I have been engaged as an expert witness in airgun lawsuits or criminal investigations. My current chronograph of choice is the CED Millennium Chronograph (www.cedhk.com)selling for only $179 as of November 2003 (generally you should not even bother getting it without the accessory infrared illuminators for about $79 unless you plan to only use it outdoors in full daylight.) The CED Millennium and the required illuminators and tripod can be transported in a good sized briefcase or pack.

The chronograph will give you velocity figures, but those figures are of very limited use without a good ballistic program on a computer. Again, many programs have passed through my facilities, but Dexadine's Ballistic Explorer seems to me to stand head and shoulders above any that I have tested - for easy of use and broad application. There are versions which will work in computers from DOS to Windows XP and the price is only about $50. You can get it from Oehler, but I suggest buying it direct from Dexadine at www.dexadine.com because the creator will actually answer your emails and calls - something that very few such makers will do. I found the instructions to be typical of so many products whose instructions were written by someone who know TOO MUCH about the product to relate to the fellow who doesn't yet know which end of the wheelbarrow to hold! But, even I was able to get going with instructions and examples, from the "How To Examples" from Dexadine's own website. You can download a free trial program for testing. This program is absolutely amazing in the things it will do and it covers the parameters so needed, and usually so neglected, for airguns - very close ranges, very low velocities, very light projectiles, etc. . Within an hour I was printing out all the graphs that I could want - even ones which showed the trajectory of a given pellet when fired up or downhill at various angles!! You really should back up the use of this program with the ballistic tables that I review in the Airgun Literature Review section of this website. The ballistic coefficient info, etc. in that reference is invaluable.

Testing Perspectives: The idea of airgun makers sending a sample to airgun writers for study is a good idea – but the big bugaboo is sampling. A reviewer runs one test on one gun and then tells everyone that here is the gospel info for all time for all guns of this model and caliber!! But he might just have had the best or worst, smoothest or tightest, etc. one ever made in that model. One just cannot project firearm thinking and sampling methods to airguns – airguns are not so uniform or consistent as are firearms firing cartridges with rigidly controlled power sources. It would be best to send at least three specimens of anything to be tested for published specs- and to depend more heavily on the factory. However, the factories are always dealing with the tightest, newest guns and may not be using the most efficient pellets for the job, or even pellets with which the shooters in another country are familiar. I relied on the shop guys (many of whom can be very rigid and unimaginative and without a statistical perspective) only so long as their results seemed to be reasonable – but whenever there was a real question, I studied the choice of guns and pellets and then did the testing myself!! And we must get rid of the idea that one must test all calibers with the same kind of pellets. While that may seem, to persons who do not understand airguns and ballistics, to be the "fairest" way of doing it – it generally is not. Different caliber pellets of the same design may vary enormously, between calibers, in length/weight ratios, diameter/weight ratios, etc. – and actually be very, very different in action! Finding pellets of the same ballistic coefficients (BC) is far more important than selecting ones of the same design. It is more important to say that the company has tested the guns with the pellets found to be most efficient for that gun in that caliber than to say that they have been blindly tested with all the same design pellets! The talking heads and perpetual critics only know what they are talking about a little bit of the time!

P.S. For a short, but excellent, note on using the Beeman R1(and caliber and pellet selection) for hunting, click on this website link by Tom Holzel, the original airgun hunting wizard:

http://www.velocitypress.com/pages/Woodchucks.php Be careful about reading some of Tom's wild personal info bombs, listed in the left column of his website. You just might blow a brain cell or two!!

And, try to find a copy, or request an interlibrary loan, of Jock Elliott's wonderful article "A Perennial Favorite - The Beeman R1" in the January 2005 issue of *The Accurate Rifle* magazine. He feels that, even a quarter of a century after it was introduced, this is the air rifle by which others are measured!

To convert from foot-pounds **to:**

Btu, multiply by .001286.
ergs, multiply by 1.356E+07.
gram-calories, multiply by .3238.
hp-hrs, multiply by 5.05E-07.
joules, multiply by 1.356.

Great "Starter" Guns

For many shooters, air guns are still "starter" guns--typically smoothbore (without the "rifling" inside the barrel that causes the bullet to spin) BB guns with short plastic stocks and sheet-metal sights. Trigger pulls on these inexpensive guns (mistakenly called air rifles by people who don't know about rifling) feel like, according to one veteran shooter of more sophisticated guns, “ the down stroke on a bumper jack.” And while the accuracy cannot be compared to more expensive guns, they serve a definite purpose: their lightweight enables youngsters to learn safe gun handling and shooting fundamentals without tiring. Scaled for short arms, they're easy for children to control and the long trigger pull is a safety device in eager, awkward hands.

But air guns, as a category, include rifles and pistols that are much more powerful and accurate than BB guns. Some, in fact, launch a pellet at over 1,000 feet per second--almost as fast as a .22 rim fire bullet! And they can definitely shoot straight. The most accurate are capable of shooting “one-hole” groups, which is to say each shot hits the target in pretty much the same place, at 33 feet (10 meters), the official range for paper-target air gun competition. Triggers on some guns, such as those used for competitive matches, can be tuned just like more high-powered competition guns. They're also adjustable for other variables important to top competitors.

Sights for air guns include scopes and precisely-adjustable metal sights--some with replaceable front globe inserts and a rear "iris" you can open or shut down (as does the iris in your eye) to accommodate changing light conditions. Yes, these are serious guns for serious shooters.

Three Basic Types of Air Guns

Besides the question of caliber, modern air guns fit into three basic groups defined by their power plant (means of pushing a pellet out of the barrel).

Pneumatic Powered Guns

Pneumatic air guns use compressed air for power. The way you get the air compressed in the air gun depends on the type of pneumatic it is. The most common pneumatic air gun is the Multi-Stroke or sometimes called Pump-up type pneumatic air gun. To get the tiny bit of air compressed in a multi-stroke pneumatic it takes, as the name implies, between two and ten strokes of the forehand pump lever to get the internal pressure needed to power the pellet out the barrel at a decent pace. Most multi-stroke pneumatic air guns are compact, recoilless and lightweight. Multi-stroke pneumatics are moderate in power.

The big down side to a multi-stroke pneumatic is all the time and effort needed to get a shot off, and a second shot is near impossible before your quarry runs or flies away. As you pump up the multi-stroke air gun each progressive pump takes more effort. Accuracy from a multi-stroke is just OK. There are too many variable in the pumping procedure to allow for stellar performance aside from the human error.

A more preferable form of pneumatic is the single stroke pneumatic air gun. As the name implies, one motion of the cocking lever is all that is needed to compress the air for propulsion. The single stoke format is used on many high-end 10 meter match air guns. Consistency, accuracy and lack of recoil are the reasons top shooters gravitate to this type of power plant. The downside is lower power, but the tack driving accuracy at close range is the reason 10-meter shooters love them.

The third type of pneumatic air gun is the pre-charged pneumatic. This is the best of both worlds. You can get variable power from low to high if you want it and you get incredible accuracy, easy cocking, no recoil and lots of shots from an air charge. The charge takes little effort on your part because the air is compressed at the dive shop into a SCUBA tank. All you need to do is siphon some of the 3000 psi out of the SCUBA tank and into the air gun via a special hose with a pressure gauge. Pre-charged pneumatics are assembled as competition air guns for the field target set, and lightweight hunters for those so inclined. Some of the pre- charged air guns are multiple shot repeaters so the air gun hunter with poor aim can get a second chance with no pumping.

Spring-Piston Powered Guns

Spring-piston air guns are the easiest air guns to shoot, maintain and own. The spring-piston gun most shooters cut their teeth on is the break barrel type. Holding the stock in one hand and breaking the air gun in half at the breech while holding the barrel with the other hand cocks the break barrel air gun. This action of breaking the air guns moves a piston backward within the receiver as well as compressing a stout spring behind it. The trigger sear clicks into a notch in the piston and holds the whole works in tension.

With a break barrel air gun the pellet is placed directly into the breech and the barrel is tipped back into position. The gun is now you are ready to fire. Take the safety off and put pressure on the trigger. When the sear releases the piston, it moves forward briskly with the power of the big spring behind it. All this action pushes a column of air forward into the rear end of the pellet sitting in the breech. The effect of all this causes the pellet to move briskly out the barrel towards the target of choice.

Spring-piston air guns are cocked by breaking the barrel, cocking an under lever, a side lever, or a top lever (over lever). Inside, the works are basically the same in principle. Things like spring rates, diameter of the compression tube (receiver) and swept area can be different depending on the gun designer’s ideas. Spring-piston air guns are very reliable and long-lived.

The worst thing you could do to any spring-piston air guns is to "dry fire" it, that is, fire it without a pellet in the breech. When this error occurs, the piston head is smashed into the front of the receiver (compression tube) because the missing pellet cannot offer the needed resistance to the air column. This resistance cushions the piston from the tremendous energy the compressed spring releases to move the air column.

Spring-piston air guns last a long time, but the springs do wear out after a while. Do not worry. A spring piston replacement and piston seal change are relatively cheap and very easy for an air gun smith to accomplish. Most firearms shooters like the recoil sensation felt when shooting a spring air gun. This is a smooth steady push to the shoulder as the spring inside the air gun does its work pushing the pellet out the barrel.

CO2 Powered Guns

CO2 air guns, as their name implies, are powered by cartridges of compressed carbon dioxide, either in the12-gram cartridge form or decanted from a bulk CO2 tank into the air gun reservoir. They have the advantage of not needing to be cocked or pumped up by hand. The use of CO2 as a power plant for an air gun is kind of interesting because it is used in some of the cheapest non-precision air guns along with the highest of the high-tech

10-meter match air guns. Kept at room temperature, CO_2 stores at approximately 900-1000 psi and is very consistent, but raise or lower the temperature and the point of impact of a CO_2 air gun can and will change.

You might wonder why - with this point of impact change situation - would these serious match shooters choose the CO_2 propulsion system to break records. They use it because it is so consistent and they have learned to manage the variables. They bring their CO_2 air guns to the range; let the air guns stabilize to the ambient temperature at the range and sight in. Right-left (windage) point of impact will be constant, but up-down (elevation) zero will vary slightly until the gun is sighted in.

The real issue with CO_2 as a power plant is for the air gun hunter or plinker. The air gun hunter who sights in on a warm day and goes out to hunt on a cool one or visa-versa will not know where the air gun will hit. A temperature change during the day can also be a problem. CO_2 air guns are generally easy to cock and recoilless to shoot. The match CO_2 air guns are very consistent and incredibly accurate at 10 meters.

Calibers and Velocity

The standard air gun caliber for target shooters is .177, although .20 caliber is growing increasingly popular for field targets, and .22 and even .25 are made for some high-power hunting air guns. Air gun velocities range from 500-1,000 fps.

For indoor target shooting and all-around plinking, low power, .177 caliber air guns are probably best: less effort to cock; less vibration, noise, and recoil (air guns don't kick, exactly, but they bounce); and cheaper pellets.

For field target, silhouette, and long-range plinking, higher velocity air guns (800 fps and above in .177 or .20) will shoot flatter, buck the wind better, and hit hard enough to knock down metal targets at 50 yards.

Air Gun Projectiles (Ammunition)

Air gun projectiles vary widely. Inexpensive BB guns shoot copper-plated steel balls (BBs) from a smooth bore. Not the best combination of materials and engineering for shooting accuracy, but, as already mentioned, still plenty good to provide untold hours of recreational shooting and enjoyment.

Hollow-base lead pellets in rifled bores perform much better and most shooters prefer the hourglass-shaped "diabolo" pellet with its solid head and hollow base. The base expands under air pressure to seal the bore and ensure full rifling contact. These pellets come in .177, .20, .22 and .25 diameters. The .177 and .22 are most popular - .177 for target shooting, .22 for hunting. A traditional steel BB, incidentally, measures .162 to .175 in diameter. New lead BBs, at .177, are more efficient because of their weight and a closer fit to the bore. But, overall, pellets are still far more accurate. There are different pellet head designs you can choose according to your intended use.

Equipment Costs

Because they use no powder or brass cases, air guns are inexpensive to shoot. A packet of

500 pellets retails for as little as $7.50. The price of a high-quality air gun, however, can startle those of us who remember lever-action Daisy's at $6.50. For youngsters starting out, a BB gun may still be a good investment and remain reasonably priced even now.

But with increasing skill comes the need for better equipment. Mid-level pellet rifles list for between $300 and $600. Pistols are about $100 less. Competition-class rifles and pistols cost as much as rim fire match guns: $1,100 and up. Modern air guns are real guns, capable of better accuracy than some firearms. They may lack the power and reach of cartridge guns, but they don't kick and bellow either. Adult air rifles and pistols handle like firearms and last as long.

Scopes

Whether you hunt, plink or shoot paper, scopes can help you score. Ordinary riflescopes are not manufactured for use on air guns, but special air gun scopes are made for short range shooting and have great internal strength to withstand the recoil of potent spring-piston guns. (Their peculiar two-way "kick" can strain a scope's innards more severely than even the recoil of a magnum center fire rifle!) For all-around plinking and hunting a 4x scope is ideal, but silhouette shooters prefer higher magnification.

Cleaning Air Guns

Because they accumulate no powder or copper residue, air guns require minimal cleaning. In fact, the bore of a pellet rifle or pistol should remain in good condition without any cleaning at all. But clean bores produce better accuracy and can even give you higher velocities, so be sure to follow the manufacturers recommendations. If you think the gun is losing power or may have been damaged, take it to a repair shop--just like any other firearm. You should not dry-fire spring-piston air guns! Without a pellet to build resistance, the air column provides no cushion for the plunger, which can cause damage as it slams home. Store all air guns uncocked. Pneumatic guns are best left with one pump in the reservoir to hold seals in place.

What is Power

Some airgun enthusiasts believe that the quality of an air rifle is derived from it's power level. Power can be calculated in a variety of ways.
For instance, a rifle's power is rated on velocity and muzzle energy, while a pellet's power is rated on its kinetic energy (knockdown power).

Determining velocity requires the use of a chronograph. Or you can also review the rated listings which are based on rifle manufacturer's information. generally using the lightest possible pellets. When using heavier pellets, the velocity decreases although the relative knockdown power (kinetic energy) usually increases. For this reason you should take the listed manufacturer ratings with a "grain of salt".

Airgun rifle power can be loosely be categorized into three groupings: Magnum, Standard and Match.
Magnum power is generally any velocity rating over 900 fps in a .177 caliber. As the caliber (size) of a pellet increases from .177 to .25 the velocity decreases. You would not expect to find your average .25 caliber air rifle shooting at 900+ fps. For this reason Muzzle Energy is also used to explain power. The higher the muzzle energy, the greater the knockdown power thus the greater the overall power of the gun.

A magnum rifle works well for general shooting and hunting. A velocity rating for a magnum air rifle can range from 850-1000+ fps. This power rating is good for hunting although that much velocity isn't really necessary for pest control and hunting.. Shooters tend to look at a rifle's velocity rating for hunting, but it is really the accuracy and kinetic energy (knockdown power) that determines the effectiveness of a hunting rifle rather than the velocity.

A rifle of standard power typically has velocity ratings ranging from 700-850 in most calibers. That will yield great results for general plinking, pest control and hunting of small game. And in fact, most spring air rifles fall into this velocity range.

The match rating can be considered a power rating under 700 fps. Generally, match rifles come in power settings of 500-700 fps and muzzle energy of less than 6 foot pounds. Do not confuse a low powered air rifle with a velocity of 600 fps with a match rifle. A match rifle is designed to be extremely accurate for 10 meters. To this end accuracy is more important than power. Generally speaking, in an out-of-the-box spring gun, the less power the gun has, the less recoil and motion it has.

Note that these power ratings and classifications do not hold true for pistols. Power in a spring gun is developed from a heavy duty spring under tension. The size of a pistol will limit the amount if power it is able to develop.

Kinetic Energy is really the most accurate way to assess a rifle's power. Power is most important to a hunter or a long distance target shooter. Kinetic Energy is the actual knockdown power at the target, not at the muzzle. A rifle with a lot of kinetic energy does a better job for the hunter. But while the target shooter isn't really concerned with knockdown power, he is concerned with the ability of a pellet to retain it's velocity and power as long as possible. The better that a pellet retains its energy (and coincidentally knock-down power) the better the pellet's trajectory will be for the target shooter as well.
When selecting a rifle it is wise to determine its intended use. Hunters should

determine the type of game and distance needed for their type of hunting purpose. Typical hunting ranges are from 20-50 yards. If your intended quarry will be small birds and ground squirrels, you might consider a rifle with 4-6 ft. lb. of power at the target. If you aren't sure how to do that, check the Our Take section on this site. It lists most of the guns in all calibers and with the results of shooting most pellets. The Our Take shows the power level in fpe (ft. lbs) at the Muzzle, 10, 25 and 50 yards. It will make a very good reference for you for most air rifles.
If you are looking to take larger game or game at a greater distance, remember that you will need the same 4-6 fpe for small game kills at whatever distance you are shooting, long or short. If your intended use is target shooting and indoor shooting, accuracy is more important than power.

For those shooters interested in power we have listed our rifles based on the three categories. Just select a power level and review the guns listed. If muzzle velocity is more to your liking however, view our listing of rifles by muzzle velocity.

Daystate Air Ranger

BSA have developed their Superten into the BSA R10

BSA R10

Spring Piston Adventures. I bought a RWS #34 in .177 about 10 years ago to shoot pigeons in a cement plant where I serve as the engineer. I shot several hundred pigeons with this budget minded yet reliable rifle. I sold it to friend. I then purchase a Beeman R9 in .177, it was nicer and I liked it fine. I gave it to my retired father, he uses it regularly on squirrels. I then bought a BSA Super Sport in .22. I had Airgunwerks install a Theoben gas ram in the BSA making for a sweet shooting rifle, it's the only magnum-powered rifle that is also lightweight. I wanted to try an underlever rifle and chose the Beeman HW-77. This HW-77 is very accurate and reliable, it delivers on all the marketing promises made of it. Then I bought an Air Arms Pro-Elite in .177. The Pro-Elite has the best build quality I have seen to date and its very hard hitting, down side is its heavy and not as accurate as the HW-77. On a whim I purchase a RWS #48 in .25. The #48 is as well made as the Beeman R series offering in my opinion. The accuracy and reliability have been excellent, like the Pro-Elite, it is heavy. These days since most of my shooting is at my range in the basement of my house, I wanted something nice for that service. I chose a Beeman R7 and it has become my favorite spring rifle. The R7 is accurate, reliable, easy to cock, quiet and most important to me, its lightweight and handles like a .22LR with mild recoil.

My gripe with spring rifles, especially magnum power class units, is they are heavier than I like and they are only single shot. The R7, HW-77, and RWS #48 have all served well and never need any repair work even though they have fired many pellets, I'm also happier with the accuracy of these three.\

PCP Air Rifle. My first PCP gun is the FX Cyclone. I wanted an air rifle with the power of the magnum spring guns, the fine shooting action of a recoilless match rifle, and the ergonomics of a handy .22LR with multi shot capability; the Cyclone exceeds these three demands.

Because a guy only needs so many air rifles, I negotiated a trade-in of my Pro-Elite with Airguns of Arizona. I chose the Pro-Elite over the RWS #48 because it had a greater trade value and was chambered in .177. Also the RWS #48 has a more ambidextrous stock suitable for a left-handed shooter and it is chambered in .25.

The Cyclone has a revolver style magazine chambered for 8 .22 cal pellets, it comes with four magazines. The lever action and safety are simple to use. The FX weighs just over 5 lbs and handles wonderfully. I ordered an extra air cylinder for field use. I also ordered the moderator, it threads on to the end of the barrel and helps muffle noise at the high power setting. The trigger is easily adjustable, though I have left mine as supplied by the factory. Its light with a clean break.

Before I got my PCP Cyclone, I was concerned about variation in velocity depending what the charge is. This is really nothing to worry about, at least for the kind of shooting I do. From 200BAR down to 120BAR, I was fully satisfied with the performance and accuracy. I don't micrometer my groups, I just get up and go look at them, either I like the grouping or I don't. With the Cyclone I am very satisfied with the tightness of the grouping, proverbial one-holers are common. Accuracy is on par with the match rifle mentioned above. Cyclone is very easy to shoot with accuracy because there is no recoil or vibration, this fact alone has made me a better shot. Also the lock time (the amount of time from when the trigger is pulled to when the pellet exits the barrel) is much less with a PCP rifle than in a spring piston rifle; short lock time makes for improved accuracy. The scope is a Simmons ProAir 4 power scope and Beeman 5030 two-piece mount.

Cyclone has a three-position power adjustment knob for power setting at 12, 20 and 27 ft/lbs. This feature was very important to me because I usually use low power for target shooting but also want high power for pest control, I'm not sure when I'll use the medium power setting. I have only shot the Cyclone in my basement, a 10 meter range, as I toggle between the power settings, the impact point of the pellet remains the same, this was a concern of mine because I don't want to adjust my scope whenever I change power settings. The rifle came with chronograph test results at the three-power setting using 16 grain domed pellets. No airgun review is complete with out technical data, here is some:
Results:
Low Power 620fps average +/-1fps 13.66 ft/lbs
Med Power 744fps average +/-5fps 19.67 ft/lbs
High Power 887fps average +/-3fps 27.96 ft/lbs

I can't tell you how thrilled I am to have an air gun that will do what the manufacture says it will do. Anyone that has been around airguns any length of time knows about the velocity games, most manufactures advertises '1000fps', but they use light weight pellets and the performance does not quite live up to the marketing hype.

The synthetic stock is a quality unit. Synthetic helps keep weight and PRICE down so I say synthetic is just fine in this application. My extra money was better spent on accessories like the moderator, scope and mounts, and the extra air cylinder.

The quality of the gun is excellent throughout. There is no vibration or recoil to break parts or cause wear and I fully anticipate this gun will be much more reliable than any spring sun has a chance to be. FX packs a lot of performance in its products at a reasonable price. FX has clever inventions and solutions to age-old airgun problems. That clever inventor is Fredrik Axelsson (founder and initial namesake of FX). Axelsson is a lefty so all the FX stuff is fully ambidextrous.

I charge my rifle with the FX hand pump. It takes 3-4 minutes to pump from 120 Bar to 200 Bar, it is not strenuous for a medium size guy like me. I would buy the compressor if I thought it necessary, but so far I'm fine with the hand pump.

The only down side of the rifle is that its easy to use a lot more pellets compared to a single shot rifle, that problem I can handle.