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## Beyond A Flash In The Pan

The wide variety of muzzleloader propellants on the market today can be confusing to the sportsman looking for the powder best suited for his particular needs. Most hunters have the ability to test for accuracy, but fewer can measure the velocity and fewer still have the ability to measure pressure. So American Rifleman asked me to evaluate these propellants for velocity and pressure and report the results.

I tested the two most popular charge weights used for hunting today with modern in-line muzzleloading rifles, 100 grs. and 150 grs. These are heavy charge weights that should only be used in modern, in-line rifles rated for magnum loads. Always consult the manufacturer to ensure that its gun is rated for such heavy loads before shooting.

To keep the test focused on the propellants and to minimize other variables, I used one rifle, a new .50-cal. Knight KRB. This gun has a 27" barrel with a 1:28" twist rate. I used Remington STS No. 209 primers throughout the test. The bullets were Hornady 250-gr. SSTs in their standard black sabots. The testing was conducted over several days. The weather remained constant with temperatures in the 90s and very high humidity. While this made the work uncomfortable, it did provide another level of consistency.

I used an Oehler Model 43 Personal Ballistics Laboratory (PBL) to measure pressure. This unit works with a strain gauge mounted on the combustion chamber portion of the rifle barrel. The gauge measures expansion of the barrel during firing, and the computer translates that into a pressure reading. The pressures measured with an Oehler Model 43 are not absolute. That's because it is impossible to calibrate the unit to measure the exact pounds per square inch (p.s.i.) when shooting a muzzle loader. Instead, it measures relative pressures that use a constant measurement for each shot fired. This allows a constant unit of measurement that allows a comparison of the pressure generated with any propellant fired in this rifle.

Velocities were measured with either the Model 43 PBL or with an Oehler Model 35P Chronograph with screens 12 ft. from the muzzle, and they were not corrected back to the muzzle. The tests were five shots. If a problem appeared, I repeated the test and used the second test in the results. As one industry ballisticsian who has shot data for several handloading manuals told me, "five shots indicates a trend, 10 shots will prove it."

When shooting the sabot bullets, I cleaned the bore between each shot using two passes with a patch saturated with Wonderlube 1000. The exception to this was when using blackpowder. The fouling left from firing blackpowder does not react well to this method of cleaning. The patches would often stick in the bore, making the rod difficult to remove. So for the blackpowder portion of test, I switched to a cotton patch lightly dampened with bore solvent, followed by a dry patch.

## Blackpowder Velocity and Pressure

### 245-gr Hornady SST in Sabot From .50-cal. Knight KRB with 27" Barrel

Powder Type	Goex FFG	Goex FFG	Goex Express FFG	Goex Express FFG	Swiss FFG	Swiss FFG	Scheutzen FFG	Scheutzen FFG
Powder Charge	100 gr	150 gr	100 gr	150 gr	100 gr	100 gr	100 gr	150 gr
Velocity @ 12 ft (f.p.s.)								
Average	1647	1839	1660	1892	1879	2065	1523	1750
High	1672	1866	1694	1921	1901	2086	1546	1784
Low	1629	1795	1629	1863	1858	2044	1500	1732
Extreme Spread	43	71	65	58	43	42	46	52
Standard Deviation	16	28	23	23	19	16	20	20
Pressure (p.s.i.)								
Average	10100	12600	11800	14100	14600	18200	8400	10900
High	10300	13500	12500	14400	15200	19300	8700	12000
Low	9700	11600	11300	13700	13900	17100	8000	10300
Extreme Spread	600	1900	1200	700	1300	2200	700	1700
Standard Deviation	300	700	500	300	500	900	300	600

All loose powders were measured by volume. For the 1 DO-gr. loads, a single powder measure was used. For the 1 50-gr. loads I used two measures, one set for 100 grs. and the second set for 50 grs. Once set, the powder measures were never moved or readjusted during the test.

When loading loose powder, the bullets were seated with firm rod pressure to create some compression of the powder column. With pellets and sticks, the bullets were seated to contact the propellant. The exception, as noted in the results, was when I crushed the sticks slightly to enhance ignition after experiencing problems with I squib loads. The gun was cleaned each evening or when the fouling blowing back into the action accumulated enough to cause the gun to malfunction.

The goal here was to test for pressure and velocity, and I did not include accuracy results for several reasons. Because I was using only one bullet design and one rifle, it would not be a fair test of the accuracy potential of any propellant. Any muzzle loader rifle will have clear preferences for bullet and propellant combinations, and those biases will influence the test. Second, firing hundreds of shots with a muzzleloader in a short time will induce shooter fatigue that can bias any accuracy results. Finally, one five-shot group per load is not a fair test of accuracy. To test properly you should fire a minimum of three groups with each load, and five, five-shot groups would be much better.

That said, I did record accuracy for some, but not all of the tests. I ran into technical difficulties with the acoustical targets I used during the test and was not able to record all of the accuracy data. In a few cases, the propellant did exhibit excellent accuracy, and I have noted that in the text. That should not be taken as an indication that other propellants were not accurate. They simply may not have been recorded.

## Blackpowder

In the perspective of today's muzzleloader hunter, it is interesting to note what was said about blackpowder in the Shooter's Bible Small Arms Lexicon and Concise Encyclopedia from 1968. "It is a low order explosive for use in igniters, primers, fuses and blank fire charges. Now almost obsolete."

The editors didn't even mention muzzleloaders. Obviously they were not visionaries or clairvoyant, or they would have known that the modern muzzleloader boom was just around the corner. In just two short years, Thompson/Center Arms would introduce the Hawken rifle and launch a modern phenomenon. Blackpowder was the only option in 1970, and it is still a viable choice today. The problem is that in the early 1990s, the government changed the designation of blackpowder to a "Class A Explosive," severely restricting its shipment and sale. As a result of that reclassification and the introduction of some excellent alternatives, blackpowder use has fallen off in muzzleloading circles.

Blackpowder's ignition temperature is much lower than any of the substitutes and the shape of its grains, with lots of edges, make it very easy to ignite. As a result blackpowder is still the best option in flintlock or sidelock rifles.

The barrel length of most modern in-lines is considerably shorter than the barrel length of most "traditional" rifles, and that difference is apparent when using blackpowder. Blackpowder works well in a modern muzzleloader design with 100-gr. charges. However, the 150-gr. charges proved to be inefficient in the 27" barrel length used for testing, with much of the powder burning outside the barrel and creating a large muzzle flash.

As a rule, blackpowder tends to produce a bit more fouling than the substitutes. The fouling is hygroscopic and attracts water, which leads to rust and corrosion. The fouling also contains sulfur, which causes that "rotten egg" smell when cleaning the gun.

There are several small companies manufacturing or importing blackpowder, and it would have been prohibitive to test them all. The companies selected offer a representative sample of the current blackpowder market.

## Goex

Goex is one of the best-known brands of blackpowder, and its flagship is the standard "red can" familiar to generations of shooters. This powder exhibited very consistent results with 100-gr. FFg charge weights, showed good accuracy potential and delivered the best accuracy. The 150-gr. FFg charge weight produced only 192 more f.p.s. than the 100-gr. charge, which is about 12 percent higher. Recoil (with an 8.1-lb. rifle) increased from 19.7 ft.-lbs. to 35.6 ft.-lbs., about an 80 percent increase.

Goex Express is a newer product and represents the company's "premium" line of blackpowder. It's designed primarily for cartridge g1111. use, but that does not preclude its use in muzzleloaders. With the Express FFg 100-gr. load, there was a very slight increase in muzzle velocity over standard Goex. The extreme spread and standard deviation numbers are also slightly higher. Blackpowders that are designed for cartridge use do not, as a rule, produce the best results in a muzzleloader. There was a velocity increase of about 14 percent over the 100-gr. charge with the 150-gr. charge.

## Swiss Blackpowder

Swiss Blackpowder has an excellent reputation with both muzzleloader and cartridge g1111. shooters for high energy, good accuracy and low fouling. Swiss with a 100-gr. FFg charge produces 269 f.p.s. more velocity than the average velocity of the other blackpowders tested. That is about a 17 percent increase in velocity. Accuracy for the 100-gr. FFg load was very good. Both the increased velocity and the excellent accuracy are consistent with previous testing of Swiss blackpowder.

The muzzle flash from powder burning outside of the barrel with the 150-gr. FFG charge made it very difficult to achieve an accurate velocity reading. I had to move the chronograph screens to the full extension of their cables and shoot with a high, overhead, noonday sun before the screens would record properly. With any other situation, the muzzle flash would cause a chronograph malfunction. When the velocities were corrected back to the muzzle to allow for the difference in chronograph screen placement, the velocity increase over the 100-gr. FFG charge was only 192 f.p.s.-or about 10 percent. The law of diminishing returns is in full effect here. This much powder burning outside of the barrel is an indication that the charge weight is far too high.

#### Scheutzen Powder

This German powder is used primarily in cartridge guns, but of course can be used in a muzzleloader. While the average velocity with the 100-gr. FFG is slightly lower than other powders, accuracy was excellent and fouling was low. The pressure was very low, and the pressure curves were extremely consistent. The pressures were also relatively low with the 150-gr. FFG load. The pressure curves are gentle with a smooth rise. With the longer duration at high pressure, this powder produces a good velocity-to-pressure ratio.

#### Blackpowder Substitutes

Pyrodex was the first successful blackpowder substitute. It was invented by Dan Pawlak and introduced by Hodgdon in 1977. Due to an accident that destroyed the factory and killed Pawlak, quantities were not shipped until 1979. The name "Pyrodex" was coined by Pawlak and created by shortening "pyrotechnic deflagrating explosive." The introduction of the in-line rifle popularized by Knight in the mid-1980s opened the door for blackpowder substitutes, and there are quite a few now, as they work far better with in-line ignition because of their higher ignition temperatures. Any successful blackpowder substitute has a government designation of "flammable solid," which allows the substance to be shipped, stored and sold under the same guidelines as smokeless powder.

#### American Pioneer Powder

American Pioneer Powder, Inc., was formed in 2002. American Pioneer acquired the patent rights for manufacturing an ascorbic acid based, blackpowder substitute propellant from Legend Products. The company manufactures loose powder in both FFG and FFFG, which are rated for burning rate rather than grain size. It also offers the propellant in a solid form it calls "Sticks." The premium line is called Shockey's Gold and is available in the same configurations.

Velocity with 100 grs. of American Pioneer FFG is 92 percent of the average of the 100-gr. blackpowder loads; if we disregard Swiss, the average is 95 percent. While this is lower velocity than many other substitutes, it is very close to the velocity performance of the baseline, which is blackpowder. It generates good velocity with very low pressures. This powder has a very favorable burn characteristic that results in a relatively flat pressure curve, as exhibited by the 150-gr. charge. Because the time to pressure is so good, it extracts higher velocity from less peak pressure.

With the two-stick 100-gr. load, the pressure curve graphs indicate that there might have been some problems with delayed ignition. This may partially explain the variation in pressure and velocity. This delayed ignition phenomenon has been observed previously, specifically in the two-stick load. This did not occur with the three-stick, 150-gr. load. The added inertia from the weight of the third stick probably helps to keep the charge in place when the primer fires and aids in ignition, and this may account for the better extreme spread and standard deviation numbers with three sticks.

The Jim Shockey's Gold FFG produced slightly higher average velocity over the American Pioneer FFG powder. There was a velocity increase of 255 f.p.s. with the 150-gr. load over the 100-gr. load, or about 16 percent.

If the bullet was seated to the top of the Jim Shockey's Sticks, ignition was poor, often resulting in a squib load. If the bullet was seated hard enough to cause some crushing of the sticks, ignition was much more positive, but pressure and velocity started to exhibit extreme swings. The test data is with the bullet seated hard enough to cause slight crushing of the sticks.

AMERICAN PIONEER POWDER (APP) AND JIM SHOCKEY'S GOLD (JSG)

Velocity and Pressure

245-gr Hornady SST in Sabot from .50-cal Knight KRB with 27" barrel

Powder Type	APP FFG	APP FFG	APP Sticks	APP Sticks	JSG FFG	JSG FFG	JSG Sticks
Powder Charge (grs.)	100	150	100 (2x50)	150 (3x50)	100	150	150 (3x50)
Velocity @ 12 ft. (f.p.s)							
Average	1498	1789	1451	1866	1590	1845	1882
High	1557	1837	1658	1956	1720	1953	2163
Low	1458	1751	1194	1754	1516	1750	1679
Extreme Spread	99	86	464	211	204	203	484
Standard Deviation	37	39	177	94	77	82	20
Pressure (p.s.i.)							
Average	7600	10400	7600	14200	8400	11300	14800
High	8200	11100	10900	16400	9700	13200	19000
Low	7000	9700	5600	12500	7500	10000	11500
Extreme Spread	1200	1400	5300	3900	2200	3200	7500
Standard Deviation	500	600	2000	1900	900	1300	3300

ABBREVIATIONS: APP (AMERICAN PIONEER POWDER), JSG (JIM SHOCKEY'S GOLD).

Black Mag3

Black Mag3 is a citrus-based blackpowder substitute available only in loose powder and in one burning rate. Black Mag has been around in one form or another for several years, and I tested some back in the mid-'90s that performed poorly. The company is under new ownership today and, as these results clearly indicate, the powder it currently offers is a great performer. In fact, volume for volume, the 100-gr. load produced the highest velocity of all the propellants tested. The standard deviation and extreme spread for velocity started to creep up a little with the 150-gr. charge. This is often an indication that the charge weight is reaching the upper limits for this propellant. Because this powder has so much stored energy, the 150-gr. load is probably excessive and should be backed off until the numbers stabilize.

Hodgdon Pyrodex and Triple Seven Velocity and Pressure  
 245-gr Hornady SST in Sabot from .50-cal. Knight KRB with 27" barrel

Powder Type	RS	RS	Select	Select	50/50 Pellet	50/50 Pellet	TS FFG	TS FFG	TS 50/50 Pellet	TS 50/50 Pellet	TSM Pellet
Powder Charge grs.	100	150	100	150	100 (2x50)	150 (3x50)	100	150	100 (2x50)	150 (3x50)	150 (2x75)
Velocity	@ 12 Ft	f.p.s.									
Average	1850	2139	1860	2175	1725	2091	1961	2166	1731	2106	1850
High	1867	2165	1874	2197	1772	2119	1973	2186	1758	2115	1882
Low	1826	2107	1832	2153	1694	2045	1954	2132	1704	2088	1831
Extreme Spread	41	58	42	44	78	74	19	54	54	27	51
Standard Deviation	18	22	18	18	35	30	10	14	23	11	19
Pressure	(p.s.i.)										
Average	14200	20100	15400	21300	13300	19700	15700	18800	14500	21500	15900
High	14800	21400	15800	22100	14400	20600	17300	20400	15000	22100	17100
Low	14000	18800	14800	20400	12300	18100	15000	17900	13500	20600	15100
Extreme Spread	800	2600	2900	1700	2100	2500	2300	2500	1500	1500	2000
Standard Deviation	300	1000	1100	800	900	1000	900	900	600	600	700

ABBREVIATIONS: RS (RIFLE/SHOTGUN), TS (TRIPLE SEVEN), TSM (TRIPLE SEVEN MAGNUM).

Goex Pinnacle

In 2005 Goex entered the blackpowder substitute market with a propellant called Pinnacle. It's offered in FFG and FFFg equivalent burning rates as well as in a solid, which is called E-Z Loads.

Pinnacle loose powder propellant performed very well. Accuracy was good, and fouling was low, especially with the 100-gr. FFG load. This propellant produces low pressures relative to the velocity produced. Accuracy was good and-except for one flier with the 150-gr. FFG that could have been shooter-induced - it produced the single best group of the test.

The solid E-Z Loads, however, were much more erratic than the loose Pinnacle powder, and the results were disappointing. The standard deviation for velocity, in particular with the three E-Z Loads is very high and, as expected, accuracy was not very good. Pressures were also erratic.

Black Mag3 and GOEX Pinnacle Velocity and Pressure  
 245-gr Hornady SST in Sabot from .50-cal. Knight KRB with 27" barrel

Powder Type	Black Mag3	Black Mag3	Goex Pin FFG	Goex Pin. Ffg	Goex Pin. EZL	Goex Pin. EZL
Powder Charge (grs)	100	150	100	150	100 (2x50)	150 (3x50)
Velocity	@12 Ft.	(f.p.s.)				
Average	2004	2342	1661	1913	1746	2105
High	2031	1661	1679	1954	1896	2284
Low	1972	2238	1627	1898	1553	1879
Extreme Spread	59	192	52	56	343	405
Standard Deviation	24	89	21	24	157	167
Pressure	(p.s.i.)					
Average	15300	25500	9900	12500	13000	19100
High	16200	26500	10500	13500	16500	24300
Low	14400	24400	8900	11900	9100	13900
Extreme Spread	1800	2100	1600	1600	7400	10400
Standard Deviation	800	1000	600	600	3500	4200

ABBREVIATIONS: GOEX PIN. (GOEX PINNACLE), EZL (E-Z LOAD STICK).

Pyrodex

The first is still one of the best, in all its forms. Good energy, good accuracy and very low fouling. The fouling does not have an accumulative effect with multiple shots like blackpowder. This, of course, makes it much easier to reload and is more compatible with projectiles that work best with a dirty barrel, like the very popular Powerbelt bullets. Also, because the degree of fouling does not escalate progressively, accuracy is improved. Accuracy with any muzzleloader is primarily a function of shot-to-shot consistency. If the degree of fouling changes with each successive shot, that introduces an inconsistency that will have a detrimental effect on accuracy. However, if the bore fouling stays relatively stable, shot after shot, that is one less variable to degrade accuracy.

The "RS" in RS powder stands for Rifle/Shotgun. This is the mainstay powder used for modern hunting muzzleloaders. The RS 100-gr. charge produced excellent velocity and consistency. Accuracy was very good, and fouling was low. The 150-gr. charge gave a 16 percent increase in velocity over the 100-gr. charge, which is more than any blackpowder produced. Pressures are over 20,000 p.s.i. on average with 150 grs., and this load should only be used in modern muzzleloaders rated for magnum charges. Accuracy was excellent and was actually slightly better than the 100-gr. charge.

Pyrodex Select is the enhanced, premium version of RS. The 100-gr. charge delivered high velocity, good accuracy and low fouling. The standard deviation for velocity remains exactly the same with both the 100- and 150-gr. loads, and the extreme spread is virtually the same. With the 150, there is a 17 percent increase in velocity. Accuracy was excellent with 150 grs.-one of the best loads tested.

In 1996, Hodgdon rocked the world of muzzleloader shooting when it introduced Pyrodex Pellets. These are pre-measured, solid "pellets" that eliminate the need to measure loose powder. Pyrodex Pellets have an "ignition cap" on one end that has a small amount of blackpowder. As a result, the fouling does contain some sulfur.

Pyrodex Pellets are offered in a variety of different sizes and power levels. This test is with 50-gr. pellets designed for use in a .50-cal. muzzle loader. With two 50/50 pellets, the performance is extremely close to that of loose Pyrodex-but with a lot less work and bother. Three 50/50 pellets probably constituted the first "magnum" three-pellet load; it's still one of the best.

In 2002, Hodgdon introduced another blackpowder substitute called Triple Seven. This new propellant produces high energy and good accuracy. The fouling cleans up with just water and contains no sulfur. Triple Seven does produce outstanding results, but there is one problem. A ring of fouling is usually left just ahead of where the bullet seats. If the shooter is cleaning between shots this is not a problem, but if you are shooting bullets that require a fouled bore, such as the Powerbelt, this can make seating the bullet difficult.

With the 150-gr. Triple Seven Ffg load, the velocity data reported in the table is for nine shots. The data were tallied after the first four shots. The extreme spread was 4 f.p.s., and the standard deviation was 1. Due to a glitch, I do not have five-shot data, but by any measure, the nine-shot or the four-shot data is outstanding.

In 2003 Hodgdon introduced Triple Seven Pellets. They are formulated so that they produce the velocity expected from other propellants used volume for volume. So, the results will be lower than using Triple Seven Ffg, which has more energy than most other propellants volume for volume. The three-pellet 150 gr. load is 375 f.p.s. faster than the 100-gr. load, which is about a 22 percent increase. Obviously this' propellant is well suited to magnum charges in modern in-line muzzleloaders.

In 2007 Hodgdon introduced Triple Seven Magnums. Because the three pellet "magnum" 150-gr. load is so popular, it decided to formulate pellets that duplicate the load with only two pellets. In spite of the initial goal, the two-pellet load did not duplicate three-pellet Triple Seven Performance in this rifle.

At this time, neither Hodgdon nor any gun manufacturer recommends using three Magnum pellets. The pressures could easily exceed 30,000 p.s.i. This is dangerous territory with many muzzleloaders, and it can be extremely dangerous in some rifles. Never use three Magnum Pellets in any rifle that is not specifically rated by the manufacturer for use with that load