Making Black Powder

Introduction:
Perhaps one of the most popular topics on pyro newsgroups and forums is the manufacture of home made black powder. Given the rising costs of commercial powder, not to mention the increasingly intrusive Federal regulations dictating the purchase and transportation of commercial BP, it is not surprising that more and more hobbyists are making their own. With good quality BP being the lifeblood of fireworks itself, making BP is often the first hurdle the new hobbyist will face.

This article marks the last in a series explaining everything you need to make your own black powder that meets or exceeds the quality of commercial powder. The following articles from past issues describe the tools and techniques you will need to use in this article:

Making your own Charcoal
Ball Mill Design
Ball Mill Construction
Ball Milling Jars
Ball Milling Media
Powder Die
Hydraulic Press
Corning Machine

The Ingredients:
Going under the names gunpowder, black powder or meal powder, this formula is old as dirt and is the foundation of all pyrotechnics. Meal powder is the name given to the finely ground powder that has not yet been processed into black powder grains. Black powder refers to the granulated powder in all its various grain sizes. Making meal powder is the first step in making black powder, and meal by itself is used extensively in many other processes as well. Most often the meal will be combined with 5% dextrin and used for priming, making black match, coating onto inert fillers for shell burst charges and wet-screening into rough powder. When making black powder, however, no dextrin is added to the meal.

Potassium Nitrate	**75%**
Charcoal	**15%**
Sulfur	**10%**
Dextrin (optional)	**5%**

In most cases you will want your meal to burn as fast as possible. This is because the major uses of your finished black powder include lifting shells, breaking shells, priming stars and making black match. Thus the stronger your powder is, the more effective it will be.

There are two major factors that will determine the strength (burn rate) of your meal powder: the integration and fine granules of the three components and the type of charcoal used. Following the guidelines given in the ball milling articles mentioned above will result in very fine and intimately mixed powder. As for the charcoal, the fastest burning powders are typically made from willow, paulownia, grape vine or spruce. The commercially available charcoals sold as "air float" typically include an unknown mixture of many kinds of wood and, while it can be used to make passable BP, it will not result in an optimal product. When burn rate is critical to performance, such as cross match on insert shells or outer primes on color changing stars, BP made from commercial air float charcoal is not recommended. Using the spruce wood commonly available as construction grade lumber (not to be confused with pine) to make your own charcoal will result in a very fast powder that meets even the most demanding applications.

The purity of the potassium nitrate is actually not as critical as some people make it out to be. Fertilizer grade nitrate, such as the type sold under the name K-Power, will work just fine for making high quality meal or BP. K-power brand typically sells for $15 per 50 lbs, making it a very economical option. However, this nitrate comes in a granular "prilled" form and must be ball milled by itself to reduce it to a fine powder before use in making BP. While the prills will reduce the caking problems associated with nitrate, it will still clump in the bag and force you to break the lumps apart before mixing.

Bulk nitrate sold in 50lb bags ($20 to $25) from commercial suppliers such as Service Chemical or Hummel contain a finer ground powder with an optional anti-caking agent added. The caking agent does not effect performance of the finished BP, does not cost extra and will eliminate the hassles of grinding the unavoidable nitrate bricks that will form due to the hydroscopic nature of potassium nitrate.

The finer the nitrate has been ground, the harder the clumps that form over time will be to break apart. Some commercial operations use agricultural grinders to pre-process clumped nitrate before milling. For the average hobbyist, placing the chunks in a large stainless steel bowl (see Figure 1) and crushing them with the end of a heavy steel rod will do the job. The chunks only need to be broken down into smaller pieces that the mill will be able to grind up. It is a good idea to only de-clump and mill your nitrate right before use rather than mill a lot at once and store it for later use. This is because the milled nitrate will only remain fluid for a short time after milling before clumping up again.

More...

Mail Passfire.com

Making Black Powder...

Page 2

Figure 1: Clumped potassium nitrate pounded in a stainless steel bowl.

Figure 2: Loading a ball mill jar.

Procedure:
There is no need to screen the materials being used to make BP, since the mill will grind and mix them quite well. Gravel sized nitrate chunks and quarter inch sized charcoal chunks can be combined and milled in such a crude state and still produce a fine powder in the end. The ingredients can simply be weighed out, thrown into a container with a lid, shaken around to mix them together roughly and then dumped into the mill jar for milling.

The procedure I prefer to use for making meal powder involves milling the charcoal and sulfur together in a 3:2 ratio first, then milling the nitrate with this C/S mixture in a 6:2 ratio to get the final product. The C/S mixture is milled for two hours, and if fertilizer nitrate is being used then that is milled by itself for 2 hours as well. The two are brought together and milled for only one hour, thus reducing the amount of time spent milling the live BP mixture.

The amount of ingredients to charge your mill with will depend not only on the size of your mill jar, but also on the density of your charcoal. This is because mill jars are charged by volume and not by weight, and charcoal can vary considerably in the volume a given amount consumes. For example, a light and fluffy charcoal made from spruce will consume about 20% more space than the same amount of commercial air float charcoal.

The calculator below attempts to help you find the right amount of materials to charge your mill with. Based on my own experience, these amounts should result in a charge that is 25% of your mill jar by volume. Using the commercial airfloat and home-made spruce as the two extremes, entering your jar I.D. and length will estimate the charge amounts for you. The numbers in the tables should change as you type in the boxes, otherwise your browser is incompatible with this script and you will need to download a newer version.

Jar I.D. 6 in.

Jar Length 8 in.

Spruce Charcoal

Step 1: Mill 1000g KNO_3

Step 2: Mill 300g C + 200g S

Step 3: Mill 600g KNO_3 + 200g C/S from Step 2

Optional: Add 40g dextrin to Step 3

Commercial Air Float Charcoal

Step 1: Mill 1000g KNO_3

Step 2: Mill 360g C + 240g S

Figure 3: Milling with dual 8" HDPE jars.

Figure 4: Screening media from meal powder.

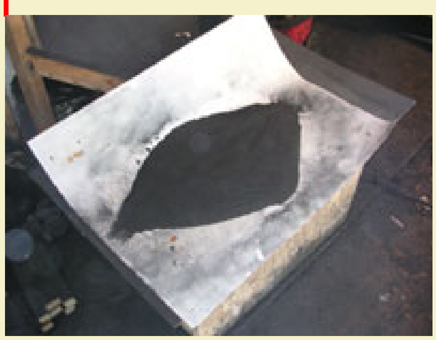


Figure 5: Using poster board for easy transfer of material after screening.

Step 3: Mill 720g KNO3 + 240g C/S from Step 2

Optional: Add 48g dextrin to Step 3

NOTE: Mill steps 1 and 2 for two hours, then step 3 for only 1 hour.

The amounts given in the table above should fill an empty mill jar 1/4 full. If it doesn't, then you will have to adjust the amounts so that it does. The jar is first charged half full of media, then the components to be milled are added as shown in Figure 2.

Note that dextrin is milled with the mix when it is required. This does not cause any clumping in the mill jar and is a lot easier than screening in the dextrin after milling.

Using a double jar mill with 6" I.D. x 8" long jars, you can mill two batches of nitrate at once for two milling sessions, giving you 4000g of nitrate. Then mill two batches of the C/S mix at once. You will then have enough pre-milled ingredients to make four jars worth of finished meal.

When milling is complete, the media is typically separated from the powder through the use of a coarse screen box as seen in Figure 4. The screen is rocked back and forth as the media pushes the powder out the bottom and onto a piece of poster board or sheet of kraft paper. The paper makes it easy to transport the finished powder into a storage container, as seen in Figure 5.

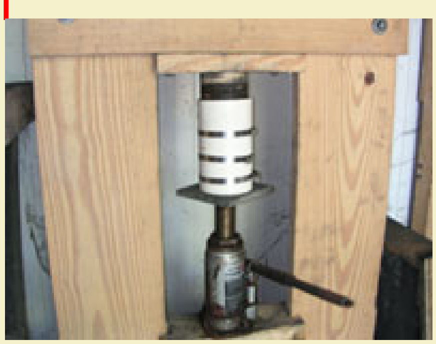
Since the media can be quite heavy, screens used for separating the media tend to wear out fast or bulge over time due to the weight. One method to increase the life of your strainer screen is to use a stronger, coarse screen overlaid with a finer non-sparking screen made of stainless, brass or aluminum. The large screen supports the weight, while the finer screen breaks up clumps and allows the media to slide around easier.

More...

Making Black Powder...

Figure 6: Meal dampened with 10% water.

Figure 7: Loading the powder die.



Pressing:
The next step in manufacturing black powder is to compress the meal powder into hard pucks that look like hockey pucks. These pucks will later be broken into pieces in a process known as "corning," which gives the final gravel like product. Pressing is an important step in the process, as this is what controls the density and thus the burn rate of the finished powder.

Density is defined as the amount of mass contained in a given volume. The ideal density to press your powder is generally accepted to be 1.7 grams per cubic centimeter. I have never made specific efforts to achieve this exact density, as I've never had any problems getting my powder to do what it is supposed to do. If you are curious about the density of your BP, measure the height of your pressed powder cylinder, weigh the dry results of the powder you make from it and enter the values into the calculator below. Note that you can enter any three values and it will calculate the fourth value, which can be useful for finding the amount of powder and depth of pressing for obtaining a specific density.

Pressed Diameter:		cm	solve for this
Pressed Height:		cm	solve for this
Dry Powder Weight:		g	solve for this
Density:		g/cubic cm	solve for this

Calculate

Since my powder has always performed well for the purposes of lifting and breaking shells, I have never fretted over density. I have measured the density out of curiosity, however, and found it to be pretty close to the 1.7 mark. Thus following the procedure given here will give you good powder without worrying about density. If you are a density control freak, you can use the calculator above to figure out the required grain height for a given weight of powder in order to obtain a density of 1.7, then mark your piston with a stop line showing where to press to.

Start by dampening your meal with 10% water that has a small amount of alcohol added to it (5%) to help break the surface tension and make mixing easier. Some will argue that 10% is too much water, but it is my experience that using a higher amount of water actually results in drier pucks that are pressed harder. It is my theory that the extra water helps lubricate the powder, allowing it to compress further. I've tried 8% and 6% and the resulting pressings were not as hard and crisp as when using 10%. Since the process described here requires that the pucks be corned immediately after pressing,

Figure 8: Compressing 8 pucks in a 12 ton hydraulic press.

Figure 9: Splitting the pucks apart.

Figure 10: The finished pucks.

Figure 11: Rough breaking the pucks by hand to feed the corning machine.

it is important to have crisp pucks with most of the water pressed out of them. The 10% moisture will actually result in dryer pucks than if you used 8%, believe it or not.

A good amount of powder to work with here is 3200g of meal. This will give you three pressings using the powder die described here, plus a forth pressing using the leftover corning dust from the first three pressings.

Rather than press single pucks one at a time, it is more efficient to press many at once. In a theoretical, friction-free world the force required to press one small disk would be equal to the force required to press many. However, friction is a very real part of the real world and the amount of force required to overcome the friction between the powder and the sides of the cylinder wall increases substantially with the length of the pressing. A 12 ton press will be required to handle pressing 8 disks with a total compressed height of about 3.5 inches.

After the powder has been dampened, place your powder die on a metal block that will support it on the press (see Figure 7) and begin loading increments of powder followed by an aluminum separation disk. The powder increments should be about one cup of powder, which will compress to give you pucks about 3/8" thick. The size of the powder increment is not that critical, as it will only control the thickness of the puck and not density. You don't want your pucks to be much thicker than 3/8" or it becomes difficult for the corning machine to break them into pieces. Thinner pucks should not cause any problems, but 1/4" to 3/8" seems to be the best range.

The thin aluminum disks, cut from soda cans, are used as separators so you can get the pucks apart when you are done pressing. They should fit into the pressing sleeve with very little gaps around the edges, otherwise the powder will adhere around the edges and "glue" the pucks togehter, making them difficult to separate.

After about four increments have been loaded, insert the rammer and compress the powder by hand. Then load the other four increments and finish with an aluminum disk on top. Compress by hand one last time and then load the die into your press as seen in Figure 8.

In addition to using a strong press, you will also need to allow plenty of dwell time when pressing. Begin by cranking the lever as hard as it will go, then return 10 minutes later and crank it again. You will find that considerably more compression can be made after it has been allowed to settle for a while. After 15 minutes you will begin to see water seeping out around the bottom of the sleeve. While this water does carry out some dissolved nitrate, it is not enough to effect performance and it is important to try and squeeze out as much water as you can before unloading the press. I allow a total dwell time of about 30 minutes, while re-cranking the jack about every 10 minutes.

Use a rag to soak up any water around the base plate of the die, then unload it from the press. The bottom and top of the powder grain will be damp, so it helps to quickly wipe this with a rag as well to keep the water from soaking back into the powder grain.

Figure 9 shows the grain removed from the sleeve with a couple of pucks seperated from it. Sometimes the pucks can be hard to seperate at first. Warming the pressed grain with your hands can cause it to expand slightly and help the pucks to crack apart. The pucks should be hard and brittle, with sharp edges when broken apart. Softer pucks will corn faster, but result in a higher percentage of unwanted corning dust. Softer pucks are also an indicator of a lower density pressing.

More...

Mail Passfire.com

Making Black Powder...

Figure 12: Corning machine in action.

Figure 13: Corning dust, 2Fg and 3FA.

Figure 14: Closeup of 3FA.

Corning:
When using the Passfire corning machine described here, breaking the pucks up into large pieces will help lower the corning time, as seen in Figure 11. These pieces are simply loaded into the screen port of the machine, which is then closed up and turned on. The machine can be seen operating in Figure 12, with a large pile of corned powder building up in front of it. The machine shown here also has a stamp mill for grinding charcoal built onto the side of it, which uses a power take-off shaft from the corning machine to power it (future tool-tip article).

It will usually take the corning machine 30 minutes to grind up the two pound batch of pucks shown in Figure 11. Before turning on the machine, prepare your next 8-puck pressing and let your press be dwelling on it while the corning machine grinds the current batch.

Screening:
The last step in making your black powder is to separate the different grain sizes you want using screen boxes. The screen sizes for the range of commercial powder sizes are as follows:

U.S. Blasting Powder Grain Size

GRADE	MESH RANGE
FA	3 - 5
2FA	4 - 12
3FA	10 - 16
4FA	12 - 20
5FA	20 - 50
6FA	30 - 50
7FA	40 - 100
Meal D	+ 50
Fine Meal	+ 100
X-Fine Meal	+140

Black Powder Grain Sizes

GRADE	MESH RANGE
Cannon	6 - 12
Saluting	10 - 20
Fg	12 - 16
2Fg	16 - 30
3Fg	20 - 50
4Fg	40 - 100

While you could go through all the trouble of screening out each of these, I find that you really only need two size ranges for pyro use. A large grain in the 2FA to 3FA range is used for lifting and breaking shells, while a smaller size in the 4FA to 5FA range is used for lifting cake items, breaking small insert shells and dip-priming operations. This way you only need three screens to do the job and less containers to store the results.

Since the powder has already passed through a screen on the corning machine, you only need two additional screens to finish the job. I use a 10 mesh screen on the corning machine, which determines the largest particle size that will be present. The powder that is collected from under the corning machine is then passed through a 16 mesh screen. The grains that sit on the 16 mesh screen are shown in Figure 14. This powder would be the equivalent of 3FA and will be used for lift and break charges. While 2FA is traditionally prescribed for this purpose, 3FA works just the same. If you wanted 2FA, you would fit the corning machine with a 4 mesh screen and then use a 12 mesh screen for the first screening. However, the coarser the screen on the corning machine is, the less fines you will get and thus the less powder you will have for cake items and insert shells. This may be more desirable depending on what type of powder you consume more of.


Figure 15: Closeup of 2Fg.

For the second screening I use a 30 mesh screen. Everything that sits on this screen is used for lifting cake items and breaking pupadelle type insert shells. This powder, shown in Figure 15, is the equivalent of 2Fg, which is a grain powder designation that covers a range between 4FA and 5FA in the blasting powder designation.


Figure 16: Closeup of corning dust.

The resulting "corning dust" is everything that passes the 30 mesh screen, as seen in Figure 16. This is a little more gritty than Meal D, and makes an excellent dusting powder for priming applications. It can also be used as the powder train when making Chinese paper fuses to give a very fast burning fuse for cross match or crossette passfires. Or you may opt to just save it for the next pressing operation and produce more grain powder from it. For every three batches of pucks that you process as described here, you will have enough corning dust left over to press a fourth batch.

Ideally the amount of corning dust generated is minimized, even though it has a number of uses. There are a number of variables that will determine the yield from the corning machine, including the dampness of the grains when they were ground, the hardness of the grains, the rigidity of the corning drum, the type of drop media used and how effectively the media strikes the powder grains. The yield for the batch used in this article was as follows:

3 Batches Made From Meal		
Corning Dust	886 g	28%
2Fg	844 g	26%
3FA	1447 g	46%

1 Batch Made From Corning Dust		
Corning Dust	310 g	35%
2Fg	224 g	25%
3FA	350 g	40%

Total Production		
Corning Dust	310 g	10%
2Fg	1068 g	34%

3FA	1797 g	56%

The data suggests that re-pressing corning dust results in slightly less yield than pressing unprocessed meal. This indicates that the aggregate mixture that makes up the corning dust results in a more crumbly puck, even though you do not notice them being any different when snapping them apart by hand.

The final table shows how much yield you will get from the entire process, which will take about three or four hours of intermittent work to produce. The grains will be nearly dry after screening and ready for use after only one day of sitting on a sheet of newspaper. Using a drybox will have your powder ready to use in only about 8 hours. The finished grains should be hard and sharp, and you should not be able to crumble them under your fingers.

Some BP makers add an extra step of tumbling their dried grains with a small amount of graphite or powdered aluminum to facilitate the ability to flow well when poured from a container. This is really not necessary since the raw grains will flow well enough for pyro use, but the graphite will give that shiny finish if you desire powder that looks like it came right out of a Goex can!