Pouderie D'Aubonne S.A.

Switzerland

SWISS
BLACK
POWDER

History.

This powder plant was founded in 1853. Located on the shore of the Lake of Geneva between Lausanne and Geneva in Switzerland.

Prior to the plant being privatized in the mid-1990's it was known as; Poudrerie Federale D'Aubonne. After privatization the plant became known as; Poudrerie D'Aubonne, S.A.

Between 1974 and 1976 the powder plant underwent extensive renovations.

In 1978 the plant installed a roller type powder press.

In 1980 the plant electrified one pair of wheel mills to augment plant capacity. One pair of wheel mills continue to be powered by a water wheel.

Raw Materials.

Potassium nitrate (saltpeter).

The source for this ingredient is: Haifa Chemicals Ltd, Haifa, Israel.
Typical analysis, Haifa Chemicals Ltd. Product Information Specification sheet.
99.8% minimum potassium nitrate.
0.2% water.
PH, 6.0 - 8.5 (1% solution)
Typical Trace Analysis, parts per million (ppm). Sodium, 160 Chlorine, 350 (as chloride)
Note: Sodium would cause the saltpeter to be rather hygroscopic. Chloride would result in a powder where the powder combustion residue would promote pit corrosion in a gun barrel.

Sulfur.

As of 1985, the source for this ingredient was shown as the province of France known as Allemagne, flour of sulfur, Honninger. Purity ranging from 90 to 95%.

Charcoal.

This ingredient is produced "in house" using Alder Buckthorn (Rhamnus frangula) wood imported from Slovenia. The wood being prepared and charred “in house”.

<u>Preparing wood for charring</u>

Figure 2. Wood stacked to dry and age.

Figure 3. Building side construction detail.

Figure 4. Wood stacked to dry and age.

The Swiss powder plant imports Alder Buckthorn wood from Slovenia where it is cut and harvested in late winter just after the ground has thawed and the sap begins to rise in the trees. It is at this time of year when the bark is most easily removed by stripping with a sharp knife.

The late winter harvesting of both Alder Buckthorn and Black Alder provides an additional income for small farmers and land owners at a time of the year when there is little else to occupy their time.

The bark on Alder Buckthorn and Black Alder is rather thin and soft so while saturated with the freshly risen sap it is easily peeled away from the wood using a sharp knife. When freshly cut, the wood will contain about 20 to 25% water based on weight of wood. When cut and placed under roof, this water content will drop considerably in a period of 2 to 3 weeks. Once the wood has been cut, peeled and partially dried it is ready for shipment.

Figure 5. Sign denoting wood type and year of purchase.

When the Alder Buckthorn wood arrives at the Swiss powder plant the shipment is stacked in the wood storage and aging shed. A sign is placed on the wood to denote the type of wood and the year that it was received into the plant.

The word "Bourdaine" is the French name for the tree we call Alder Buckthorn or Glossy Buckthorn Alder.

The wood is aged for 3 years prior to being used to make charcoal in the plant.

An interesting note in this wood topic.

The Alder Buckthorn is cut in late winter just after the sap rose in the tree with the thawing of the ground. The sap at that time of year being rich in sugar which the tree had stored in its root system. This sugar acting as food for the tree while it sets out flowers and develops leaves to the point where they would produce the sugar the tree needs for growth. This sugar remains in the wood after it has dried. The finished charcoal, in addition to having carbonized cellulose would also contain some caramelized sugar. Simple experiments have shown that this inclusion of caramelized sugar is of benefit in the charcoal in the finished powder.

Wood charring.

Figure 5. Wood cradle.

When wood is removed from the storage stacks it is cut to a specific length to fit into a cradle.

During the charring process the wood is held in the cradle. The wood must be tightly packed to minimize air space in the bundles of wood.

Once the cradle is loaded with wood it is then wheeled out of the shed, to be loaded into the charring cylinder.

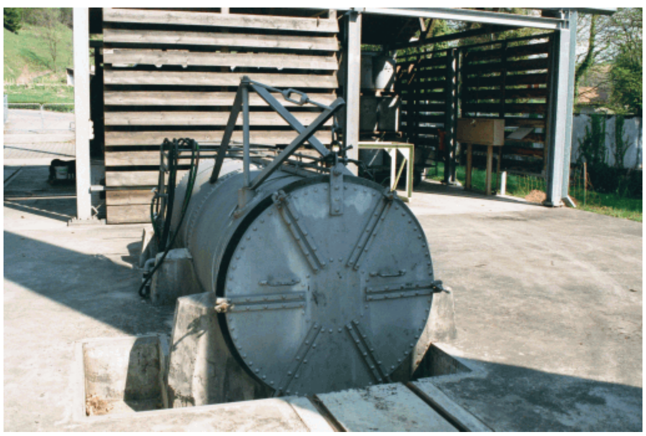

Figure 6. Wood charring cylinder.

In 19th century English and U.S. writings on black powder production they mentioned "pit coal" and cylinder coal". "Coal" being the then common term for charcoal. The "pit" method pre-dates the cylinder method. With the pit method, charcoal for gunpowder was produced in the same way charcoal for iron furnaces was produced.

"Pit coal" is inferior to cylinder coal" in gunpowder applications.

The photo above shows the end of the charring cylinder holding a lid. The lid is removed, the charring cradle is rolled into the cylinder, the lid is then replaced and tightened to seal the cylinder. Sealing the cylinder to exclude air.

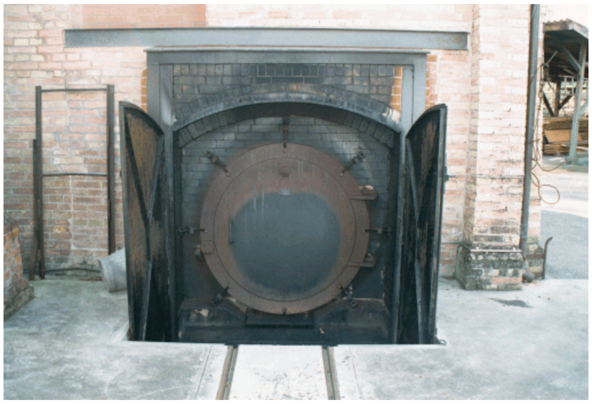

Figure 7. Charring retort and cylinder hatch.

The charring retort is essentially a large brick oven. The hatch in the oven covers the opening into which the cylinder loaded with wood is placed.

The hatch is removed and the cylinder loaded with wood is rolled into the retort. The hatch is then replaced and the hatch cover is dogged down to seal the retort chamber.

Figure 8. Charring operation layout.

This photo shows the physical lay out of the wood storage, preparation and charring operation.

The wood storage building is just visible in the upper left comer of the photo.

The wood cradle is filled while in the wood storage building.
The tracks allow the filled cradle to be wheeled out and inserted into a cool, empty charring cylinder.

The filled cylinder is then moved, on the tracks, to the opening in the charring retort and then pushed into the retort.

After the charring is complete the cylinder is withdrawn from the retort. The hot cylinder is then rolled to the cooling pit, where the cylinder rests in the photo, where it is sprayed with water to cool it and its contents.

The brick stack in the photo carries away waste heated gases from the retort heater and the fumes given off from the charring cylinder during the charring process.

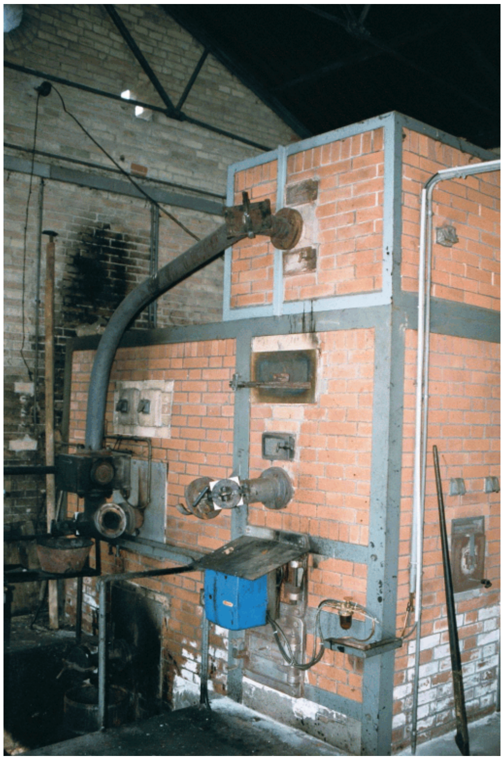

Figure 9. Retort, inside building.

This is a view of the retort from inside the wood charring building.

The heat source is in the lower left comer of the photo.

After the cylinder is placed in the retort and the retort then sealed, it is necessary to heat the cylinder.

When the temperature of the wood, within the cylinder, reaches about 280 degrees Centigrade the carbonization, or destructive distillation, of the wood will begin.

As carbonization proceeds, the chemical changes within the wood produce heat. The outside heating is then reduced. If a desired charring temperature is to be maintained , the retort operator must balance the outside heating against the heat produced by the wood itself during the charring process.

Figure 10. Temperature control.

This photo shows the controller used to maintain a specified temperature within the retort.

The alder buckthorn charcoal used by the Swiss powder plant requires very specific physical and chemical properties. This temperature controller is crucial to maintaining a specific temperature range that will insure the desired properties in the finished charcoal.

A historical note.

The "cylinder retort" method used at the Swiss powder plant came into use, in the U.S., in the mid-19th century. In the photos presented here, the scale of the operation is that of a small gunpowder plant. This same cylinder retort method was used extensively in the manufacture of "wood chemicals". By the close of the U.S. Civil War an industry began to grown in southern New York state and northern Pennsylvania where maple and beech woods were charred for the chemicals they produced during the charring process. The charcoal being something of a by-product which was then sold off at a price well below what it would cost the average gunpowder plant to produce.

The cylinder retorts used in the wood chemical industry were considerably larger than that are seen in these photos.

In this cylinder retort method the heat from the fire is not applied directly to the metal cylinder holding the wood. The fire heats a brick chamber into which the cylinder has been placed. This produces a more uniform charring of the wood within the cylinder. Uniformity of charring within the mass of wood in the cylinder is critical with the type of charcoal used in the Swiss powder. This requirement for uniformity of fixed carbon content also mandates that the wood used be no larger than a certain diameter. One does not want portions of the finished char to have a high fixed carbon content while another portion might have a low fixed carbon content.

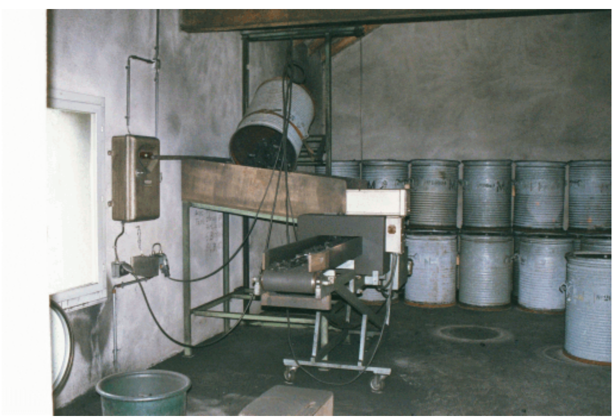

Figure 11. Finished charcoal in steel drums.

When the cooled charcoal is removed from the charring cylinder it is placed in steel drums that are then sealed.

Freshly charred wood is highly reactive with air. Given access to air, the charcoal will form a mono molecular layer of oxide on its exposed surfaces. This evolves heat. Given unrestricted access to air, the charcoal may undergo spontaneous combustion.

In the above photo we see sealed metal drums used to store the charcoal and one being used to weigh out the charcoal for a batch of powder going to the wheel mills.

Charring conditions.

Sporting powder.
300 to 320 degrees Centigrade for 8 hours which gives a fixed carbon content of about 65% in the finished charcoal.

Fireworks powders.
500 degrees Centigrade for 6 hours which gives a fixed carbon content of 70 to 75% in the finished charcoal.

Charcoal properties.

In the preparation of very fast-burning sporting powders it is necessary to obtain a very fine ingredient particle size in the finished powder. Typically with a sporting powder, roughly 70 to 80% of the charcoal would be ground to a particle size range of 2 to 10 microns.

The relative hardness of a charcoal will depend upon the conditions under which is was charred. The higher fixed carbon chars being rather hard and difficult to grind in a wheel mill. Low fixed carbon chars are rather soft and easy to grind to the required particle size in the wheel mills.

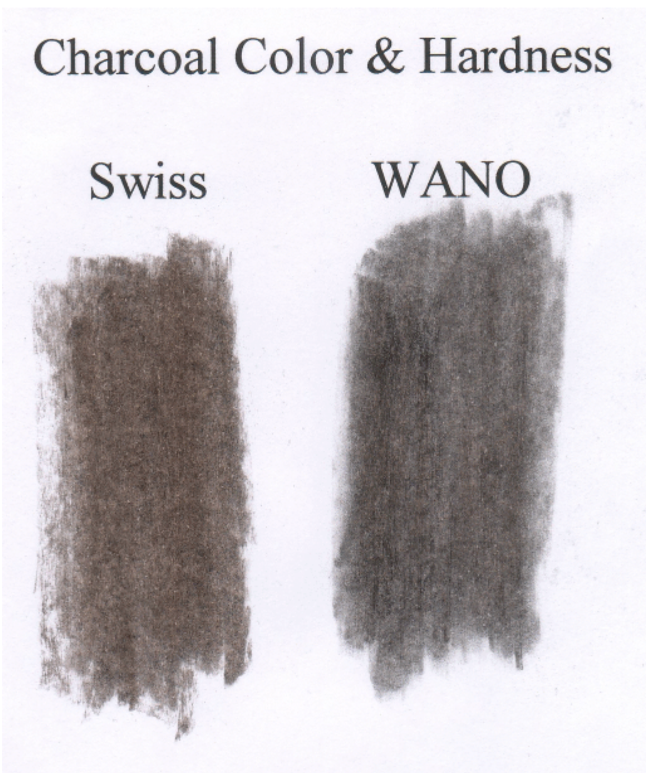

Figure 12. Charcoal color comparison.

WANO, in Germany, uses a commercially prepared Alder charcoal with a fixed carbon content ranging from 75% to 80%.

The Swiss Alder Buckthorn charcoal has a fixed carbon content of about 65%.

The respective colors reflect the fixed carbon content of each char. The lower fixed carbon content of the Swiss charcoal being seen as a dark brown color versus the black color of the higher fixed carbon content WANO charcoal.

When a piece of each charcoal is rubbed on white paper the differences in hardness become readily apparent.

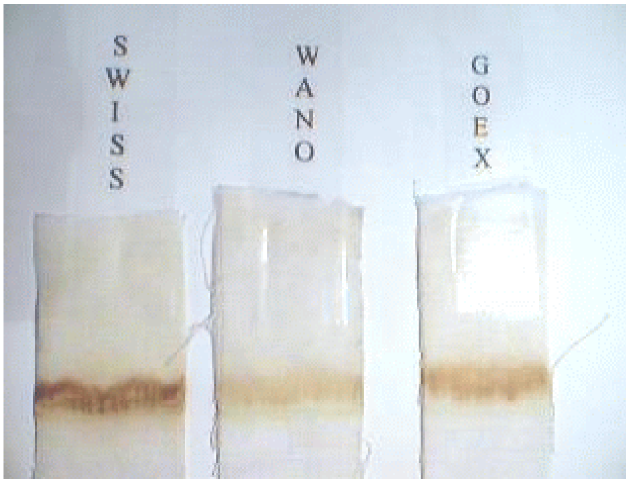

Figure 13. Acetone extractions.

If the charcoal used in the gunpowder, or the finished powder, is subjected to a leaching with acetone, the acetone will extract certain hydrocarbons from the charcoal ingredient. Primarily any creosote present and/or coloring matter specific to the type of wood used to make the charcoal.

The function of the acetone extraction test is to look at the creosote content, if any, of a particular charcoal sample or sample of the finished powder.

The gunpowder produced in the Swiss powder plant is the only presently produced black powder that is truly "moist-burning". This is the direct result of the creosote content of their in-house produced charcoal. When you bum pure carbon you get no water as a product of combustion. Bum a liquid hydrocarbon and some water will be produced during powder combustion.

During the charring of the wood, lignin in the wood is converted to various phenolic-structured hydrocarbons. One of these being creosote. The creosote produced during the destructive distillation of wood is different from that produced by the destructive distillation of coal or by the "cracking' of petroleum crude oils.

When the Swiss limit there wood charring temperature to 300 to 320 degrees Centigrade they insure that the creosote produced during the destructive distillation process is retained within the charcoal. Allowing the charring temperature to rise above 320 degrees Centigrade will cause the creosote to flash off and leave the cylinder in the cylinder exhaust gases. By 350 degrees Centigrade, all of the creosote will have been flashed off and lost through the cylinder stack vent.

The Swiss charcoal will show about 8% by weight of creosote while other brands will show none to only a slight trace.

Wheel mill batch preparation.

The potassium nitrate and sulfur are screened and run over a magnet to insure that no "tramp metal" or pieces of foreign material get into the batch of powder being prepared.

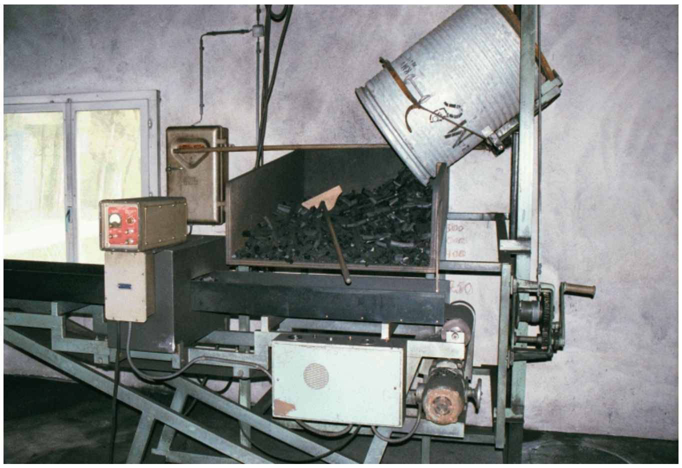

Figure 14. Charcoal preparation.

Here we see charcoal being weighed out from one of the charcoal storage drums.

The charcoal is moved from the bin onto a slowly moving belt. The charcoal then passes under a metal detector.

Depending on where the wood had been collected, one may see nails, fence wire staples or even bullets that had been fired into a tree. Pieces of Figure 14. Charcoal preparation. charcoal that "trip" the metal detector would of course be discarded.

<u>Ingredient proportions based on powder type.</u>

Blasting powder: 75 parts saltpeter, 10 parts sulfur, 15 parts charcoal.
Artillery powder: 77.5 parts saltpeter, 13.5 parts sulfur, 13.5 parts charcoal.
Fireworks powder: 77.5 parts saltpeter, 9 parts sulfur, 13.5 parts charcoal.
Sporting powder: 78 parts potassium nitrate, 10 parts sulfur, 12 parts charcoal.

With black powder, the saltpeter is considered to be the source of calories of heat during powder combustion while the charcoal is the source of gases.

By altering, or juggling, ingredient ratios, the number of calories of heat may be altered along with the total volume of permanent gases produced. In addition, the proportion of carbon dioxide to carbon monoxide is altered.

All of this was once described as the "expansive force" produced by the powder. A blasting powder would be expected to exhibit a maximum combustion temperature of 1800 degrees C while a sporting powder would produce a maximum combustion temperature of 2200 degrees C. Theoretical combustion temperature of black powder usually being shown as 2350 degrees C.

Wheel-milling.

The Swiss powder plant continues to operate one pair of wheel mills powered by a water wheel. The remaining wheel mills being powered by electric motors.

Water-powered wheel mills.

Figure 15. Water-powered mill building.

This is a view of the water powered wheel mill(s) building. The sluice proving water to the water wheel is seen in the lower right of the photo.

Just to the left of the operator is the crank handle and gears to raise or lower the gate in the sluice. The sluice gate controls the flow of water to the water wheel that drives the pair of wheel mills.

Figure 16. Water sluice.

Here in the United States one only sees a water-powered wheel mill building as a reconstructed historical exhibit. The only such example of a water wheel powered wheel milling building may be seen at Eleutherian Mills, a reconstruction of the original du Pont black powder plant located a few miles north of Wilmington, DE as part of the Hagley Museum and Library. And in this reconstruction the water wheel does not actually drive a wheel mill. The one operating wheel mill in that exhibit is powered by a water turbine.

It would be apt to state that this water-powered wheel mill building at the Swiss plant is something of an historical treasure.

Figure 17. Water wheel gear.

Figure 18. Water wheel in operation.

The operation of the water wheel is done by simply controlling the flow of water to the wheel. The mill operator uses the sluice gate control seen in Figure 15. Water flowing through the sluice may be diverted away from the water wheel when it is not in operation. The diversion channel is seen to the left of the building in Figure 18.

In Figure 17 we see the large gear that is driven by the water wheel shaft. That gear in turn drives a vertical shaft that then drives a large gear overhead.

Figure 19. Overhead mill drive gears.

The large gear in the right side of the photo is driven by the vertical shaft seen in Figure 17.

This gear in turn drives the gear mounted on top of the wheel mill drive shaft.

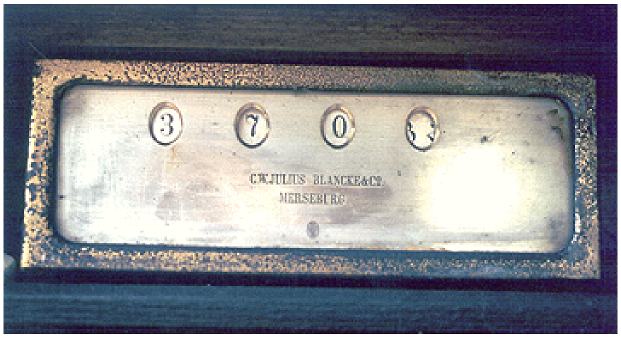

Figure 20. Wheel mill revolution counter

As a source of power, water wheels leave a bit to be desired at times. Periods of drought may curtail the operation of water wheels and floods may destroy them.

The performance of a finished batch of powder depends upon how well the ingredients are incorporated at the ill. In essence, how much "work" is put into the batch.

With electrically powered wheel mills the mill is turning at a set speed that does not vary. Water wheel power will give different wheel mill speeds depending upon the amount of water being directed to the water wheel.

So with a water wheel powered wheel mill the amount of milling performed on the batch is regulated by the total number of revolutions the wheel mill would make on the batch being worked in the mill pan.

In the Swiss powder plant the milling cycle is expressed as number of "tours" of the mill, rather than as a period of time.

A mechanical "tour" counter is seen in Figure 20.

900 tours for blasting powder.
1000 tours for artillery powder.
1200 tours for fireworks powder.
1200 tours for sporting powder.

These data are for a "5-ton" wheel mill. Each wheel of the mill weighing about 5 tons each. Some "5-ton" wheel mills have wheels that actually weight 5.5 tons each.

For a sporting type powder the normal batch size would be 25 kilograms, or 55 pounds.

The moisture content of the batch at the start of the milling cycle is 10% by weight of batch.

Wheel milling- basics.

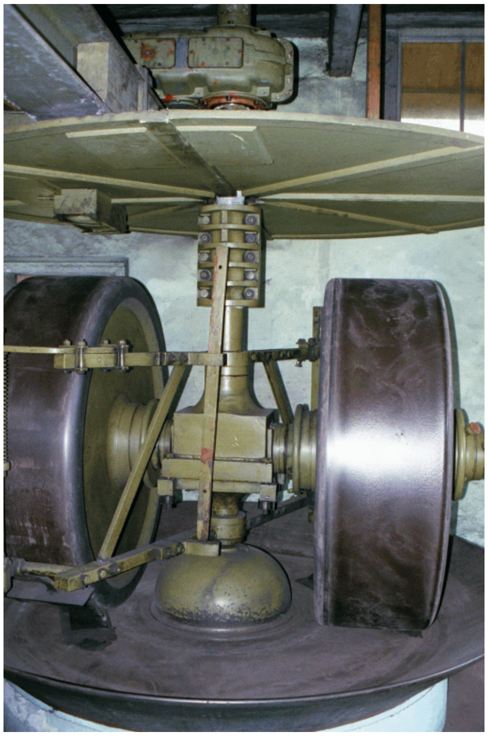
Figure 21. Wheel mill design.

This is something of a typical mill of the "5-ton" design.

During the rotation of the mill the wheels run in a very tight circle. This gives the wheels an action best described as smearing or mulling.

The wheels are pressing down on the powder in the mill pan. Keep in mind that each of the wheels will weigh from 5 tons to 5 and one half tons. This provides a very intense pressure smearing action.

With up to 10% by weight of water in a batch, the mass being worked in the mill is somewhat putty-like in nature. The pressure/smearing action produces a lot of internal friction within the mass of powder being worked in the mill pan. Crystals of potassium nitrate are broken down to ever finer sizes by both the pressure and the shearing action within the mass being pressure smeared.

Reduction in the particle size of the charcoal and sulfur is the result of a combination of shearing, or tearing, and a cutting action produced by the crystals of potassium nitrate with sharp broken edges.

The moisture content of the batch during the time in which the batch is worked is important in ingredient particle size reduction, in addition to safety issues.

If the batch moisture content is too high it will form balls or "clinkers" that hang on the edges of the wheels or on the sides of the mill pan. Too little moisture and there is the danger of a wheel mill explosion. Evaporation of water, during the milling, does act to cool the batches being worked since the physical working of the batch will cause heating of the batch.

The moisture content of the batch governs the consistency of the batch. This has an effect on internal friction within the batch while it is being worked under the wheels. This batch consistency will effect the rate and extent of ingredient particle size reduction.

Figure 22. Wheel mill size.

This photo gives some perspective on the size of one of these wheel mills.

This wheel mill is driven via an electric motor located outside the building. A gear box is seen on top of the mill's center shaft with the gear box drive shaft entering through a hole in the wall of the building.

The cover over the wheel mill prevents foreign objects from dropping down into the batch of powder being worked in the wheel mill. Were a foreign object to fall into the batch, large enough to fill the gap between the wheels and the bed pan it would be almost certain to cause the batch to "explode" in the mill's bed pan.

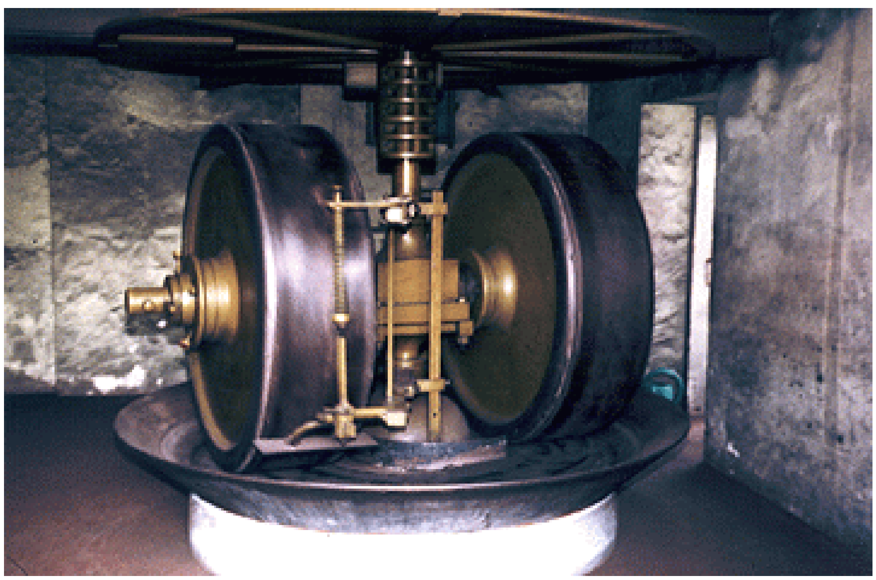

Figure 23. View of wheel scraper.

During the wheel milling cycle, some chunks of powder may adhere to the running surface of the wheels. A scraper is mounted across the face, just off the surface, of the wheel to remove any clinging powder.

Figure 24. View of wheel scraper and batch plough.

A bracket hold the wheel face scraper and also holds a plough used to push the powder into the path of the next wheel. The mulling action of the wheel mill causes the powder to move away from under the wheels. A portion going toward the center of the mill pan and a portion going toward the outer edge of the wheel pan. A pair of ploughs push the powder back toward the center of the wheel paths to insure a maximum of working of the batch by the wheels.

When the wheel-milling of the batch has been completed the mill is stopped and the batch removed from the wheel mill pan, usually using wooden or non-sparking implements.

Figure 25. Wheel mill “cake”.

Preparing wheel-mill "cake" for pressing.

As the powder comes from the wheel mill it is in the form of a mixture of powder and compacted pieces called "mill cake".

This form is not really best suited for the powder pressing operation. These pieces of cake must be broken down into smaller pieces prior to the pressing of the powder. This may be done manually, by hand.

Powder Pressing

This roller type powder press was installed in the Swiss black powder plant in 1978, replacing the traditional vertical plate powder press.

This roller (Laminoir) type powder press is unique to the Swiss bp plant. The only such powder press in operation. Figure 26 shows the feed end of the powder press. Broken down mill cake is fed onto the slowly moving rubber belt in a specified thickness. The powder then passes under the roller. The roller operating at up to 30 metric tons of pressure.

Figure 27 shows the pressed powder end of the press. After passing beneath the roller the powder cake will break off and drop into the collection box

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Figure 26. Roller type powder press, feed end.

seen in the photo.

The cake produced by the powder

press ranges in thickness from I cm. to 0.5 cm. depending on the type of powder being pressed.

Powder from the wheel mill is low in density and lacks the required degree of cohesiveness required in a propellant powder. During powder pressing the volume of the powder is reduced by about 35 to 40% of its original volume as it comes from the wheel mill. The pressing operations both compacts and consolidates the powder. This imparts a high degree of mechanical strength in the pressed powder.

The press densification and consolidation of the powder does not require that the powder be held under great pressure for any length of time, as would be seen in the typical plate press. Imparting mechanical strength in the powder comes about after the water has begun to evaporate from the pressed powder cake. As the press cake is exposed to air there will be a slight loss of moisture and a bonding within the mass that provides the desired degree of mechanical strength to the powder.

Corning (granulating)

Figure 28 is a side view of the coming mill in use at the Swiss black powder plant.

Figure 28. Corning mill

This coming mill uses 3 pairs of rollers as may be seen by the light colored gear covers on the side of the coming mill.

Broken up powder press cake is carried by a conveyor to the feed section on the top of the corning mill. Generally, the top two sets of rollers would have shallow grooves across the face of the rollers while the bottom pair are smooth faced rollers. As the powder passes through the top pair of rollers into falls into the "bite", or gap, between the second pair of rollers and then down through the third pair of rollers. As the powder moves from the top pair to the bottom pair the gap, or opening, between the rollers decreases. The powder cake being broken down into desirable grain sizes in stages.

The bottom pair of rollers drops the "green grain" powder into a conveyor belt that carries it off and drops it into a collection box.

Screening

The screening unit is located in the coming mill building. This is a dual screen unit. Each unit, or side, has a screen in it. Both units are suspended on rods. The screen units are moved, or oscillated in a circular, or rotary, motion. Grains able to pass through

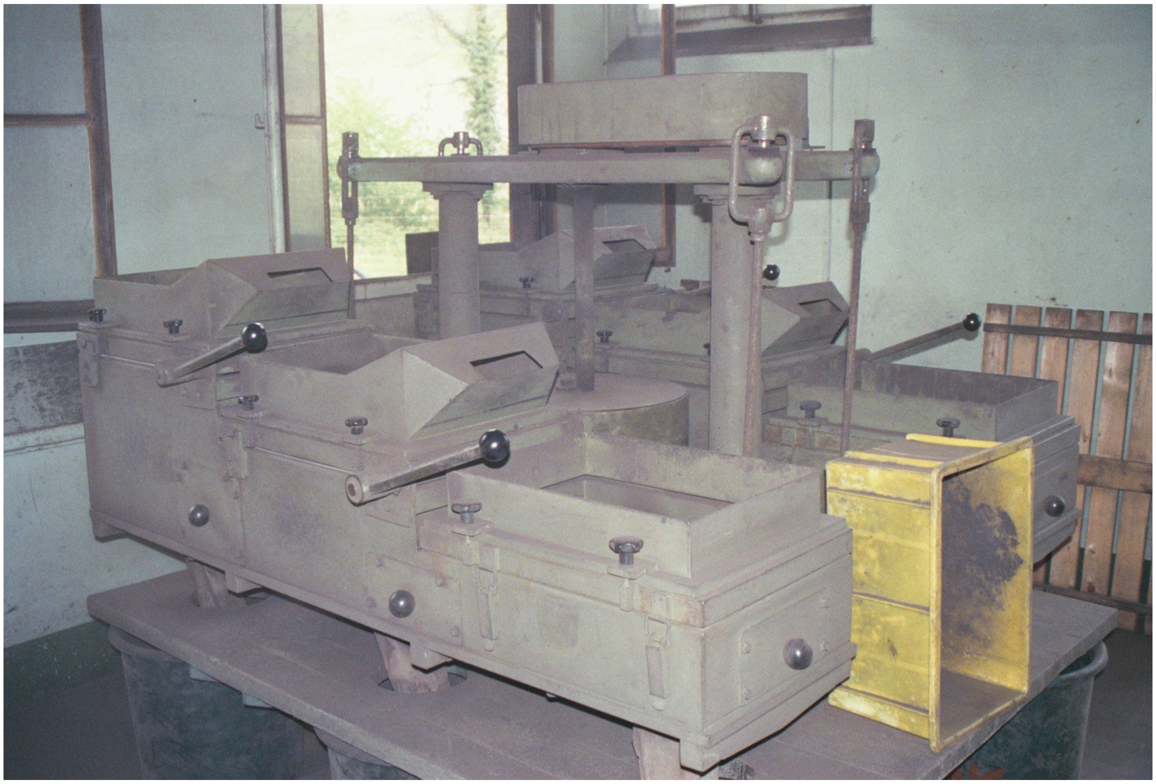

Figure 29. Powder screening unit.

the screen in the first compartment fall down through the cloth chute into a collection bucket. Those grains that will not pass through the screen then move on to the next screen. Rom the layout of these units it appears that the green grained powder is first passed over a fine screen. Oversized grain then moving to the next larger screen in the next compartment. If it fails to fall through that screen it then passes over to the last compartment.

Grain sizing.

The Swiss black powder plant using a grain sizing system that is not used in the U.S. This different grain sizing system has caused a considerable amount of confusion with American black powder shooters who try and relate the Swiss grain sizes to those commonly used in the U.S. for well over 100 years. The following data gives a comparison of the Swiss grain sizes to those more commonly seen in the U.S.

U.S.	Swiss	Screen openings in mm	Rough conversion to U.S. screen sizes.
4 Fg	#1	.226 - 0.508 mm	32 mesh - 60 mesh
3 Fg	#2	.508 - 0.870 mm	18 mesh - 32 mesh
2 Fg	#3	.670 - 1.36 mm	12 mesh - 24 mesh
1.5Fg	#4	.900 - 1.36 mm	12 mesh - 18 mesh
1Fg	#5	1.20 - 1.60 mm	10 mesh - 14 mesh

Compared to U.S. screen sizes.

3Fg	20 mesh - 50 mesh
2Fg	16 mesh - 30 mesh
1Fg	12 mesh - 16 mesh

The Swiss 1 Fg is slightly larger than U.S. 1 Fg
The Swiss 1 & 1/2 (1.5) Fg is very close to a U. S. 1 Fg.
The Swiss 2Fg is slightly larger than a U.S. 2Fg.
The Swiss 3Fg is larger in size compared to a U.S. 3Fg.
The Swiss 4Fg is not nearly as fine as a U.S. 4Fg.

With the sporting powder bum rate and ballistic strength in the Swiss powder it becomes necessary to deviate from our 3 grain sizes used in propelling charges to give a greater degree of flexibility in dealing with various bore sizes and projectile weights.

It should be pointed out that prior to 1890, C&H used 9 different grain sizes to cover the total size range of our present 4 U.S. grain sizes.

In the U.S. grain sizing system: the average size of 3Fg is half the average size of 2Fg, while the average size of 2Fg is half the average size of 1 Fg. In effect, 3Fg is half the size of 2Fg while 2Fg is half the size of 1Fg.

Polishing powder

Powder that has not been polished, or glazed, is generally considered to be unsuited for use as a propellant powder in a firearms. That is not to say that it cannot be used, it simply does not work as well as a polished powder when it comes to accuracy with the gun.

Polishing barrels vary in size in the black powder industry. Some holding as much as a ton of powder.

Figure 30. A pair of polishing barrels.

Figure 30 shows a pair of polishing barrels at the plant in Switzerland. Hatches for the loading and unloading of the barrels are seen in the photograph.

The wheeled pans beneath the barrel catch the polished powder when the polishing cycle is completed and the hatch is opened to empty the barrel.

In this microscope photo we see grains of powder from the corning mill and prior to polishing.

These grains are characterized by sharp angular edges and rough grain surfaces.

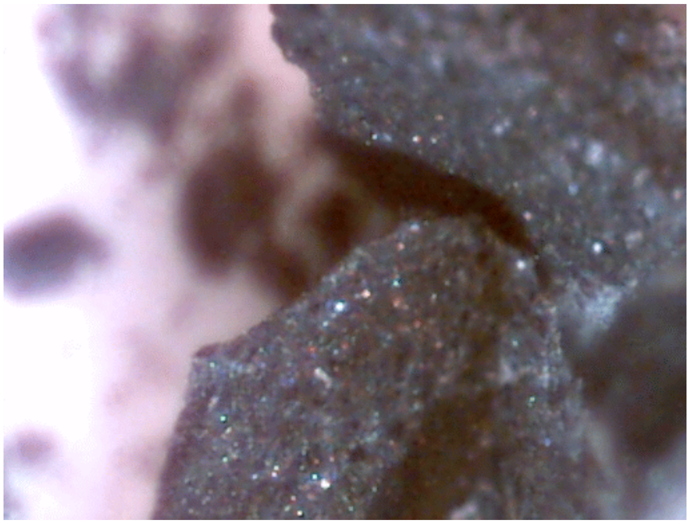

Figure 31. Corned powder grains prior to polishing.

Grains of powder, such as these, are prone to edge breakage and surface material shedding during shipping and handling.

While such grains are easy to ignite in the gun, flame spreading through the powder charge may be somewhat erratic from shot to shot.

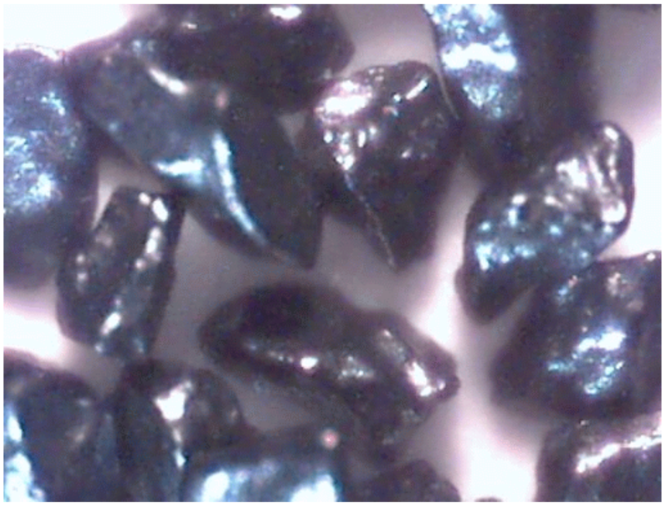

Figure 32. Swiss 2Fg at a magnification of 60X.

In Figure 32 we see Swiss 2Fg at a magnification of 60X.

With polishing, the grains may be characterized by well rounded edges and smooth, hard grain surfaces.

It is important to understand that the polishing, or glazing, of black powder grains has nothing to do with the graphite coating of black powder grains. Glazing and graphite coatings are two different things.

When the grains of black powder are placed in the polishing barrels, at the Swiss powder factory, the moisture content of the powder is about 8%. That, according to a plant tour guide published while the factory was still under government ownership.

As the grains of powder tumble in the rotating polishing barrel the edges are rounded and the grains' surfaces are "polished". This "polishing" consists of a smoothing of the surfaces and a compacting of the surfaces of the grains. The surfaces of the grains then becoming more dense and less porous compared to the interior portions of the grains.

The barrel rotates at 20 RPM with Sporting powder being polished for 24 hours in the barrel.

The thickness and degree of hardness that is imparted to the grains' surfaces is determined by the moisture content of the powder and the amount of time that the grains are tumbled in the barrel.

In the firearm, glazing has two beneficial effects. Well polished grains will "nest" together more uniformly in a powder charge. In a firearm, the amount of space occupied by a charge will show some shot to shot variation. Even with weighed charges. A well polished powder will show a more uniform "degree of confinement" on a shot to shot basis.

The glaze formed on grains of black powder, through "polishing", will act as an ignition deterrent coating on the grains. While the ignition and flame spreading through the charge is somewhat slowed by heavy (thick) glazing, the process is more uniform as a result and contributes to a greater degree of inherent accuracy in the powder.

Drying Powder

The powder left the corning mill at about 8% moisture content. During the polishing process the heat generated by the rubbing together of the powder grains drove off some of its original moisture. After polishing, the moisture content of the powder would be between 2 and 3%.

Figure 33. Drying room with drying tray racks.

Powder to be dried is spread out on cloth that is suspended in frames to form trays. With the powder grains resting on the cloth, air is free to circulate over the exposed powder grains and under the cloth on which the grains rest.

Figure 34. Steam pipes that heat air under the racks.

The photo on the left shows the steam pipes running beneath the drying racks that heat air to dry the powder spread out on the drying tray cloth.

The room is heated to a temperature of 40 degrees centigrade to dry the powder. Typical drying time would be about 24 hours in this room or until the moisture content of the powder falls to about 0.5%.

Following drying, the powder is ready to be packaged. The type of packaging used depends on where the powder will be shipped to. Europe allows the use of plastic bottles holding 1 kilogram of powder. U.S. packaging calls for 1 pound containers, either tin cans or plastic bottles are allowed.

United States Packaging

Figure 35. Tin can.

Figure 36. Plastic bottle.

Tin cans were used for the U.S. market up until mid-2001. The plastic bottle shown in Figure 36 then became the standard container for powder orders shipped to the United States. The plastic bottles being produced in Finland. These plastic bottles are of an exceptionally high quality in terms of uniform wall thickness and in the specific type of high density polyethylene (HDPE) used.

Powder Properties and Performance

The black powder produced by Pouderie D'Aubonne, S.A. in Switzerland is a true sporting type powder. During the 19th century the use of the term "sporting" powder denoted a particular type of powder. The term, at that time, had a different context, denoting properties and performance different than those that would be found in rifle type powder or musket type powders.

Black powder is extremely versatile in that by alter its chemical composition and physical properties the combustion characteristics of the powder can be varied greatly. Anything from a simple gas generation composition to one that is very fast and very hot in a gun.

During the 19th century there were three basic types of black powder produced for use as a propellant powder in small arms. These were; musket, rifle and sporting. The designation denoting differences in burn rates. Musket being the slowest. Sporting being the fastest.

To put that in perspective with three different present brands of black powder commonly available in the United States.

Test rifle: .50 caliber Lyman Great Plains Rifle (Investarms), flintlock.
.490 balls, .020" patching with Lehigh Valley Shooting Patch Lubricant.
Pact Professional Chronograph, 15 feet from the muzzle.
Charges measured by volume, measure calibrated to throw 100 grains weight of water at the 100 setting on the sliding stem.

The powders used are all 3F. The grain size being nearly identical in all 3 brands, with the Swiss 3F being just a bit more coarse in size, compared to the other 2 brands. So in this test there is little difference in grain size influence in the results with the 3 powders.

Using an 80 volume setting on the measure.

1877 fps ave., Swiss 3Fg (1997 production lot) (1.08 g/cc)
1671 fps ave., Goex 3Fg (1997 production lot) (0.97 g/cc)
1469 fps ave., Elephant 3Fg (1997 production lot) (1.09 g/cc)

In the comparison between the Swiss 3Fg and the Goex 3Fg we see that the Swiss powder is about 13% faster than Goex. The Goex 3F being about 12% faster than the Elephant 3Fg.

Historically, 19th century, a sporting powder was a minimum of 10% faster than a rifle type powder as a rifle type powder would be about 10% faster than a musket burn rate powder when the grain size of the 3 were equal. The differences in velocity being a difference in burn rates and ballistic strengths.

Test rifle: .45 cal. Southern Mtn Rifle by TVM, flintlock.
.440 balls, .020" patching with Lehigh Valley Shooting Patch Lubricant.
Pact Professional Chronograph, 15 feet from the muzzle.
Charges by volume measure, measure calibrated to throw 100 grains weight of water at the 100 setting on the shaft.

Using a 60 volume setting on the measure.

1855 fps ave., Swiss 3Fg, 1997 production.
1616 fps ave., Elephant 3Fg, 25/99 production.
1511 fps ave., Elephant 3Fg, 1998 production.
1552 fps ave., WANO 3Fg, 1999 production.
1630 fps ave., Goex 3Fg, 1998 March production.

Loading density of the above powders.

Swiss powder loading density ranges from 1.06 to 1.08 g/cc.
Elephant loading density covered a range of 1.10 to 1.15 g/cc.
Goex loading density covered a range of 0.99 to 1.02 g/cc.
Wano loading density was 0.95 g/cc on this sample of powder.

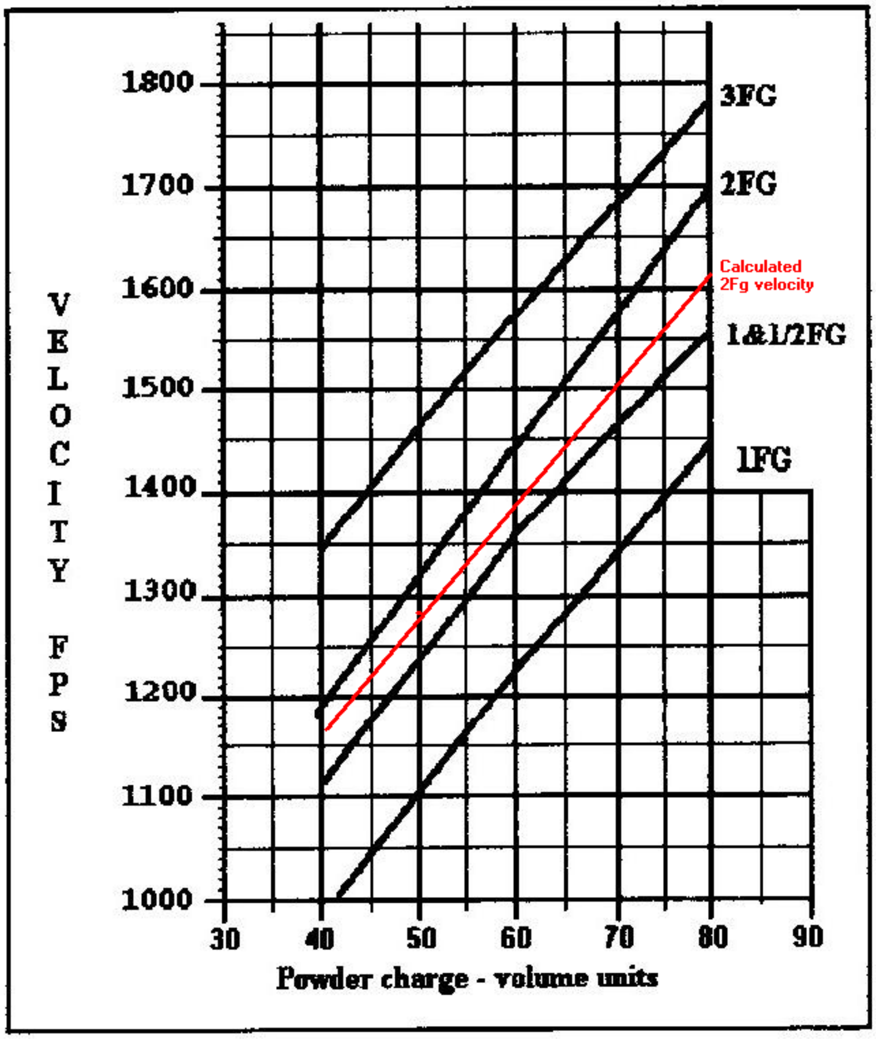

Figure 37. Velocity comparison of the Swiss powders.

Test rifle is a Lyman (Investarms) Trade Rifle. Percussion ignition, .50 caliber. Charges by volume.

If the velocity data for both the 1Fg and the 3Fg are averaged, the red line on the graph is produced. This would represent a calculated 2Fg velocity if the Swiss 2Fg followed the American system of grain sizing.

With the American grain sizing system, 2Fg is half the size of 1Fg while 3Fg is half the size of 2Fg. Using grain size range average size as a guide. With the American grain sizing system the graph line for 2Fg would fall mid-way between 1Fg and 3Fg.

In Figure 37 we see how the Swiss deal with a very "strong" powder when it is to be used in a wide range in bore sizes and a wide range of loading configurations.

The Swiss 2Fg grain size is slight smaller than what a calculated 2Fg would be based on the size of their 1Fg and 3Fg powders. The Swiss 1&1/2Fg is slightly larger than a calculated 2Fg grain size.

The velocity graph reflects this method of dealing with a fast, strong powder when having only 3 grain sizes might present a problem with certain bore sizes and certain loading configurations.

Keep in mind that prior to 1890, C&H dealt with this by producing 9 grain sizes covering the same overall range as our present 4 sizes in the American grain sizing system.

Comparing Swiss 2Fg to other brands of black powder in the same grain size.

Test Rifle: .50 caliber Lyman Trade Rifle, 28" barrel, 1 in 48" twist.
Percussion ignition, CCI #11 Magnum caps.
.490 Speer balls, .020" #40 cotton drill patching.
Lehigh Valley Shooting Patch Lubricant (Lestom Laboratory version).
Pact Professional Chronograph, 15 feet from the muzzle.
Adjustable powder measure, calibrates to 100 grs. weigh of water at 100 setting.
Weather: 55 to 60 F @ 45% R.H.

	KIK 2Fg Yr. 2000	Goex 2Fg 99NO03B	Elephant 2Fg Lot 045, 25/99	Swiss 2Fg 001, 111.199
40 gr.	1085 fps ave.	967 fps ave.	1046 fps ave.	1242 fps ave.
60 gr.	1339 fps ave.	1214 fps ave.	1281 fps ave.	1481 fps ave.
80 gr.	1553 fps ave.	1371 fps ave.	1480 fps ave.	1667 fps ave.

Mid-way through the year 2001 the Swiss increased the burn rate of their sporting powder destined for the United States importer.

Test rifle: Lyman Trade Rifle, percussion ignition with a 28 inch long barrel, rifled 1 turn in 48 inches. Using CCI #11 Magnum caps, Speer .490 balls, .020" #40 cotton drill patching and Lehigh Valley Shooting Patch Lubricant. Pact Professional Chronograph at 15 feet from the muzzle. Charges by volume measure using a Treso adjustable powder measure calibrated to throw 100 grains weight of water at the 100 setting.

Swiss 2Fg, Lot #001, Date Code 111.199 (Packed in tin cans).
60 - 1432 fps ave.
80 - 1699 fps ave.

Swiss 2Fg, Lot #1-1002, Date Code 06-01 (Packed in plastic bottles)
60 - 1504 fps ave.
80 - 1763 fps ave.

The main competition for the Swiss powder at that time being the domestic supplier, Goex, Inc.

Shooting on the same day as above using the same rifle and loading configuration.

Goex 2Fg, 01JA15B (Packed January 15, 2001).
60 - 1284 fps ave.
80 - 1480 fps ave.

Goex 2Fg, 01OC05B (Packed October 5, 2001).
60 - 1317 fps ave.
80 - 1494 fps ave.

Goex 2Fg, 02MA04B (Packed March 4, 2002).
60 - 1358 fps ave.
80 - 1526 fps ave.

KIK 2Fg (Imported from Slovenia by Goex in May 2000)
60 - 1330 fps ave.
80 - 1543 fps ave.

Elephant 2Fg, Lot S-032, Date Code 004/01
60 - 1245 fps ave.
80 - 1444 fps ave.

Bore fouling properties.

The Swiss sporting type black powder is noted for being a “moist-burning” powder. At present, the only supplier of black powder that is in fact a true moist-burning powder.

In shooting with the “common” powders there is no water produced as a product of combustion. For any moistness in the bore fouling they are entirely dependent upon moisture in the air that enters into the barrel after the projectile and spent propelling gases leave the barrel. If the Relative Humidity is 30%, or less, the residue left by the common powders is for all intent non-hygroscopic. The powder combustion residue will be dry. As the Relative Humidity rises above 30% the powder residue will then exhibit hygroscopic behavior. At about 70 to 80% R.H. the residue will exhibit deliquescent behavior.

With the moist-burning property of the Swiss powder the powder’s combustion residue will not be dependent upon atmospheric conditions for any moistness in the bore fouling.

In some rifles it may be found that when shooting with the Swiss powder the rifle will produce more consistent velocities and a higher degree of accuracy if the bore is not wiped between shots.

This moist-burning property also gives the illusion of a greatly reduced amount of bore fouling with the Swiss powder.

With the Swiss powder, compared to the common powders, you use less of the Swiss powder to achieve useable velocities in the gun. So there will be less bore fouling when you are loading less powder to begin with.

I used the term “illusion” of greatly reduced amounts of bore fouling. It is possible to actually measure the amount of bore fouling left by a particular powder in the bore of certain guns. In this work a .45 caliber TVM Southern Mountain Rifle was used. This rifle barrel was breeched using a flat-faced breech plug. A soaking wet cleaning patch may be run down the bore, right onto the face of the breech plug. When pushed slowly down the bore, all of the powder residue will dissolve into the water being retained in the patch. The powder combustion residue being roughly 99.9% soluble in water.

In this work, 10 cleaning patches are oven dried and weighed. At the shooting range they are then saturated with water. After each shot fired the bore is slowly swabbed with one of these wet patches. The used patches then being placed in a little plastic bag. They are later oven dried to a 0% moisture content and are again weighed. Calculating the recovered bore fouling weight against charge weight then gives a numerical value for powder combustion residue left in the bore with each shot fired, using a 10 shot average.

One day of shooting with the .45 caliber TVM rifle produced the following data. The temperature during the shooting was in the 40 to 50 degree F range.

3Fg, KIK, 2.5% of the original charge weight as recovered bore fouling.
3Fg, Goex, 2.5% of the original charge weight as recovered bore fouling.
3Fg, Elephant, 2.7% of the original charge weight as recovered bore fouling.
3Fg, Swiss, 3.2% of the original charge weight as recovered bore fouling.

To explain this data.

With black powder, the amount of solid particulate matter produced by powder combustion will be, to some extent, influenced by the proportion of potassium nitrate in the powder. All of the potassium, from the potassium nitrate, will form solid particulate matter during powder combustion. There being no potassium-based gases in this.

Both KIK and Goex were formulated with 75 parts of potassium nitrate. Elephant was formulated with 76.5 parts of potassium nitrate. The Swiss powder is formulated with 78 parts of potassium nitrate.

Based on the difference between the Goex/Kik and Elephant it would be logical to expect the Swiss powder figure to be about 2.9% of the original charge weight. But when the Swiss powder produces water as a product of combustion, the residue left in the bore will have some added weight by the water it retains.

This is not to suggest that the moist-burning property is in any way objectionable. In most black powder firearms it is a highly desirable property in the powder.

Accuracy.

The Swiss black powder quickly gained a reputation for unmatched accuracy in the U.S. market. When the shooter works up a load for a gun that gives the best accuracy, the Swiss powder will show a very low extreme spread (ES) in velocity in a string of shots. With the Swiss powder the uniformity of pressure development is unmatched by any other brand of black powder.

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