## Drying and polishing.

In most black powder manufacturing plants the grained powder is dried and then polished in two separate operations. In other plants the grained powder is dried and polished in a single operation. With this in mind, drying and polishing will be treated as two separate operations.

Drying, an overview.

After the powder has been "grained" in the corning mill the moisture content of the powder grains will vary from roughly 1.5% up to 2.5%.

Removal of this moisture is simply a matter of passing heated air over the grains of powder. In heating the air, used to dry the powder, the relative humidity of that air is greatly reduced. As this "dry" air flows over and around the grains of powder the water (moisture) in the grains will evaporate from the surfaces of the grains and be carried away in the moving air. As water evaporates from the surfaces of the powder grains there will be a migration of water from the interior portions of the grains to the surfaces until a desired moisture content is achieved in the grains of powder.

In the drying of black powder the temperature of the powder grains must not be allowed to rise above 180 degrees Fahrenheit. It is at this temperature where a small portion of the sulfur will begin to volatilize. A small portion of the sulfur will begin to turn from a solid to a gas without going through a liquid phase. Black powder heated to temperatures above 180 degrees F will give off a strong odor of sulfur as a result. The loss of sulfur will reduce burn rates in the powder and will result in small but rapid chemical changes in the powder. The finished powder will be inferior in performance if dried at a high temperature.

## Tray drying black powder.

When duPont first built their original powder plant along the Brandywine Creek in Delaware they tray dried corned powder in the open on cloth covered trays. This was inefficient in that it was subject to changes in the weather. This was also more labor intensive compared to the common method used in Europe at the time.

Drying houses in European powder plants were constructed from stone. A fireplace was built into one end wall with the firebox outside of the building. The fireplace, or stove, heated the wall. Having a fireplace or stove in the building was simply too dangerous. The heated wall then heated the air in the drying house. The old term for drying the powder was "stoving the powder".

These drying rooms, or drying houses, are now heated by steam or hot water run through pipes in the drying rooms. With the use of steam, or hot water, to heat the drying rooms the boilers are now set up some distance from the powder building in order to minimize any dangers.

**Figure 48.** Drying house.

This is one of the powder drying houses at the S/A Pernambuco Powder Factory in Brazil.

The man in the left of the photo stands next to the pipe carrying steam to heat the building. The tracks are used for the carts that carry powder to and from the building.

**Figure 49.** Drying house interior.

This is a view of the interior of the drying house. Trays containing grained powder spread out on cotton fabric are stacked in shelves. Near the bottom of the photo the steam coils that heat the air in the building may be seen.

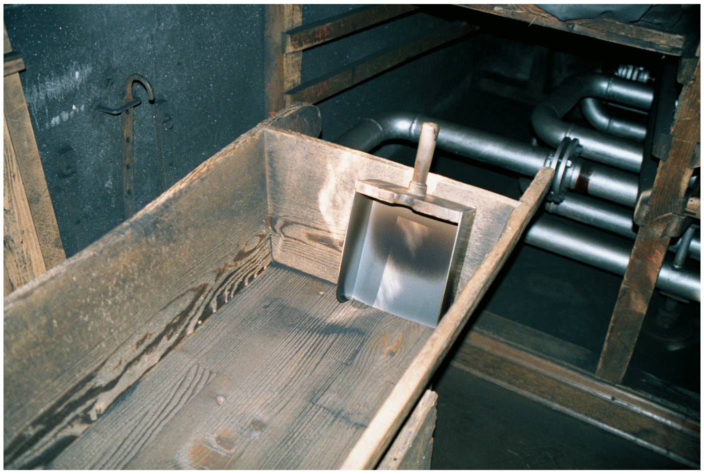
Figure 50. Tray hopper.

When the powder reaches a specified moisture content the trays are removed from the shelves and are brought to this hopper. The powder trays are then dumped into the hopper where a bag beneath the hopper collects the dry powder.

The dried, bagged powder is then ready to be transported to the polishing barrels.

Figure 51. Drying racks and trays.

Drying house with tray racks in the Pouderie D' Aubone S.A. powder plant in Switzerland.



Heating pipes are seen behind the trough used in the handling of the powder when it is placed on the cloth covered trays or removed from the trays.

**Figure 52.** Heating pipes visible under the racks.

Polishing powder.

When Lammot duPont developed his sodium nitrate blasting powder he also developed a way to dry and polish black powder grains at the same time. Blasting powder had to be produced as cheaply as possible. Reducing production costs required a reduction in the number of man hours involved in the handling of the powder during the processing of the powder. Drying the powder and then polishing the powder required a good deal of manual labor. Tray drying powder is labor intensive in that the cloths must be put on the trays. The powder is then spread out evenly on the cloths. During the drying process it may be necessary to stir the powder around on the cloths to speed up the drying. Then the dried powder must be removed from the cloths. The cloths will also have to be washed after a certain period of use.

Then you have the amount of labor involved in the polishing of the powder. The powder must be loaded into the polishing barrels and when finished dropped out of the polishing barrels into bags.

Lammot duPont simply redesigned a polishing barrel. Increased its length. Polishing barrels rotate when in operation. Lammot duPont mounted the lengthened polishing barrel on trunnions. One end had a hollow trunnion through which heated air could be blown. A flapper vent on the other end of the barrel allowed the moving air to escape. As the barrel rotated the powder grains tumbled in a stream of moving heated air. Carrying away moisture given off by the powder grains.

In the rotating barrel you have a large mass of grained powder. The mass of powder grains is constantly tumbling. The powder grains rub together.

When black powder is dried there is a migration of moisture from within the grains to the surfaces of the grains. The water, or moisture, arrives on the surfaces of the powder grains as a saturated solution of potassium nitrate and some of the mineral matter from the charcoal ingredient. As the water evaporates from the surfaces of the grains it leaves this water-soluble material behind.

As the powder grains tumble and rub together these deposits are compacted and fused into a hard glass-like film that encapsulates the grains. The friction between the grains rounds off sharp edges and smooths the film forming on the grains surfaces. A well polished powder without a graphite coating on the grains will give the appearance that the grains had been dipped in molten glass and allowed to cool. This is where the term "glazed" powder originated. Glazed as in glass.

This "glazing", or polishing, of the powder grains imparts a great deal of mechanical strength to the surfaces of the powder grains. Glazed powders are less prone to shedding surface dust during shipping and handling of the powder.

With black powders produced for use as a propellant charge in small-arms the glazing is crucial for accuracy in the powder.

The glaze will slow the rate at which the powder charge ignites and burns. The skin, or glaze, on the grains is composed of potassium nitrate and charcoal minerals. The skin is not combustible. The skin does not contain sufficient charcoal and sulfur to support powder combustion. To gain ignition and combustion of the grain of powder a spark or flame must first melt through some point in the skin.

This ignition of a grain of black powder has been described in this manner. A spark contacts the surface of a grain. It must have sufficient heat to melt a point on the surface of the grain. Aberdeen Proving Ground's Ballistic Research Laboratory studied this using high-speed photography. The surface will appear to melt. Infra-red photography shows what appears to be a puff of smoke being given off by the melting surface material. This would be traces of moisture in the skin on the surfaces of the grain. The so-called "puff" of steam being only visible to the IR photograph. The melted portion will then appear to boil. This is where the potassium nitrate has been heated to the point where it decomposes and gives off oxygen. The area then appears to glow orange. Then actual powder combustion begins and the process proceeds rapidly across the surfaces of the grain and then will quickly spread to other grains in a mass of grains.

The glaze acts to slow the ignition of a powder charge in the gun and moderate the rate at which flame spreading proceeds through the charge. Promoting what is known as uniform pressure development in the gun. This gives more uniform pressures in a series of firings of the gun.

Poorly glazed powders, compared to those that are properly glazed, will usually show poor accuracy, throwing one or more "fliers" in a string of shots.

During the polishing, or glazing, of the powder there will be an increase in the density of the powder as a result of the tumbling of a great weight of powder in the barrel. The surface regions of the grains being compacted by the tumbling of the grains in the polishing barrel.

A study was performed on this at the S/A Pernambuco Powder Factory. Dried powder going into the polishing barrel gave a loading density of 0.90 grams per cubic centimeter (g/cc). As the polishing cycle proceeded samples of powder would be removed from the barrel at periodic intervals. In a 6 hour polishing cycle the loading density had increased to 1.10 g/cc. At 8 hours in the barrel the loading density had increased to 1.15 g/cc. This last figure being excessive in that when the loading density reaches this level the burn rate of the powder is depressed considerably. In most powders intended for use in black powder small-arms the ideal loading density range is around 1.05 g/cc, plus or minus 0.03 g/cc.

Microscope photographs of various powder grains shows the effect of polishing on the grains surfaces.

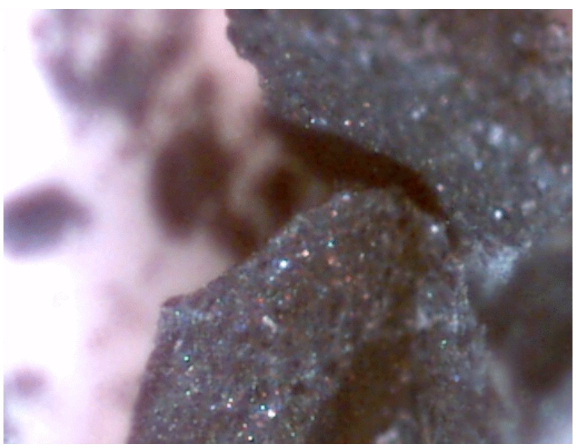


**Figure 53.** Unglazed powder.

**Figure 54.** KIK 2Fg, 2000 shipment.

The KIK black powder brought into the U.S. in the year 2000 exhibited a low loading density. In the range of 0.90 to 0.93 g/cc. This shipment was noted for throwing “fliers” in a string of shots. In a string of 5 shots you would get 3 rounds into the point of aim with one a bit off and then another way off. The low loading density, the roughness of the grains’ surfaces and the questionable accuracy simply reflect an inadequate polishing of the powder grains.

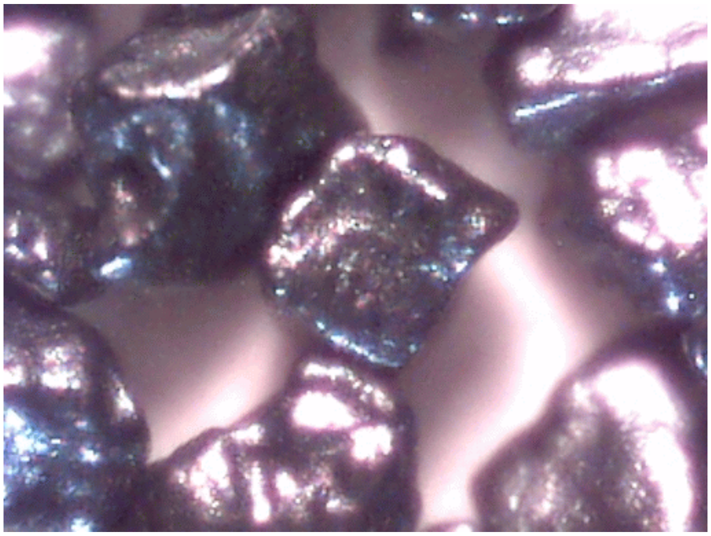


Figure 55. Swiss 2Fg, 2000 shipment.

Of all of the black powder producers supplying the U.S. market the Swiss powder plant does the best job of grain polishing.

The Swiss powder quickly developed a reputation for extreme accuracy.

That is not to say that powders not polished as well as the Swiss powder cannot shoot accurately it is simply a point of how hard one must work at getting them to do so.

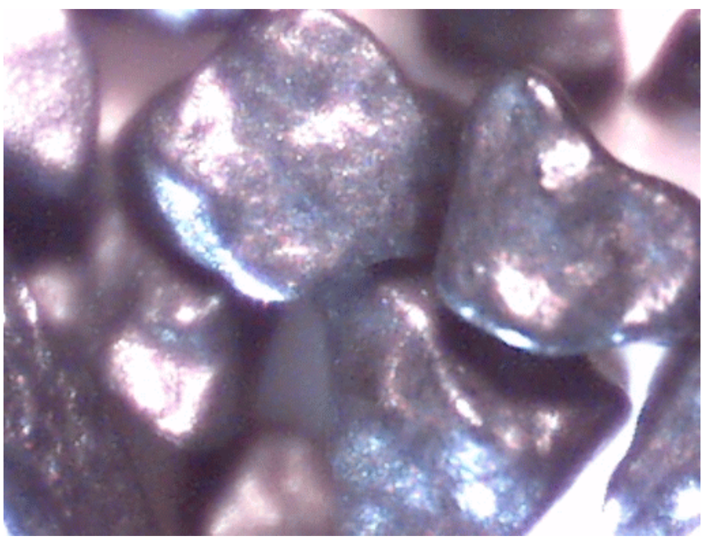


Figure 56. Elephant 2Fg, Date Code 25/99.

The S/A Pernambuco Powder Factory, who made Elephant brand black powder normally did a very good job of polishing their powders.

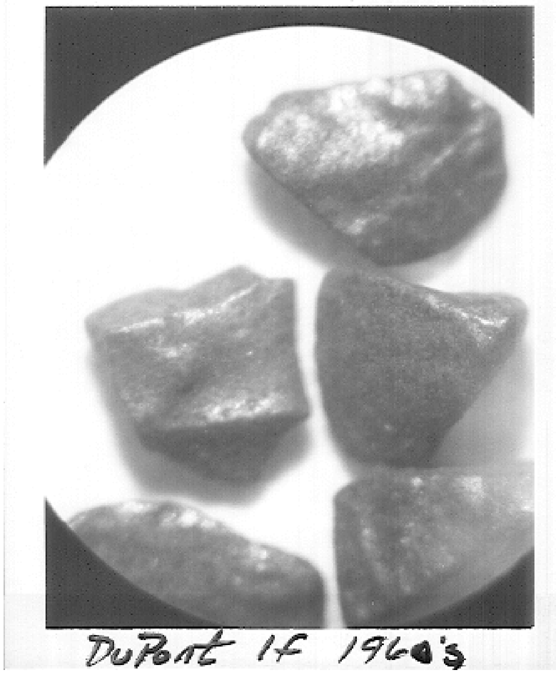


**Figure 57.** Moosic duPont 1Fg.

A microscope photo of some 1Fg made by duPont at the Moosic, Pa powder plant in the 1960's.

**Figure 58.** January 1988 GOEX 1Fg.

In 1988 there was a severe drought in eastern Pennsylvania. GOEX's use of untreated well water to produce the powder resulted in powder with poor chemical stability. The resulting powder grains had soft surfaces.

When the powder grains are tumbling in the drying/polishing process used by GOEX the surfaces of the grains would erode and form dust in the rotating barrel. The dust particles would then agglomerate and fuse together to form perfectly spherical grains as is seen in the microscope photograph. These spheres are low in density and will give an erratic burning to the powder.

These spherical powder grains having been seen only in drought period production lots of powder out of the Moosic, PA plant.

**Figure 59.** January 2001 GOEX 3Fg.

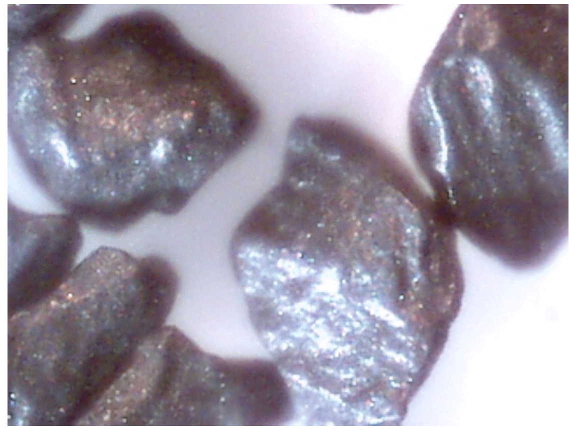


Figure 60. First lot of GOEX Cowboy.

The above photos represent GOEX powder production out of the Minden, LA black powder plant that they opened in early 1998.

Drying and polishing in one operation.

As previously described. Lammot duPont developed the rotary dryer/polisher in the U.S. to produce blasting type powder. At that time their small-arms powders continued to be dried and polished in two separate operations. By the beginning of the 20th century the small-arms powders were also switched over to the single step process.

In this "duPont" process the powder dries while tumbling in the barrel with heated air being blown through the barrel. Near the end of the drying/polishing time they will stop the barrel and add graphite. The barrel is then started up again. When the powder is almost dry the inject a "puff" of steam into the air being forced through the hollow trunnion into the barrel. This will slightly dampen the surfaces of the grains and bond, or fuse, the graphite to the surfaces of the grains. Once the powder has been dried to a specific moisture content the powder will be removed from the polishing barrel.

Later in the 19th century this concept was used by some European powder producers with a slight modification.

When the Chilworth Powder Company was established in England in the late 19th century they controlled the humidity level of the heated air being blown into the rotating drying/polishing barrel. This allowed them to control the moisture content during the drying and polishing of the powder grains. This gave them a great deal of control over how well the finished powder would be polished, or glazed. In the glazing process small variations in powder moisture content will effect how well the finished powder will be glazed. By controlling the rate at which the powder dries and the moisture content during the initial phase of polishing they could minimize lot to lot differences in the depth and smoothness of the surfaces of the powder grains' glazing.

Polishing barrels.

**Figure 61.** Polishing house.

Polishing house at the S/A Pernambuco Powder Factory near Recife in Brazil.

The building housed a pair of polishing barrels.


**Figure 62.** Polishing barrels in their stand.

Here we see the pair of polishing barrels in their stand.


Figure 63. Loading and unloading hatches.

Bags of grained, or corned, powder are hoisted up to the platform. Hatches in the barrels are removed and the required amount of powder is poured into the barrels.

The hatches are then sealed, closed and tightened down.

The barrels are then rotated for the required length of time.


**Figure 64.** Outlet hatches for the finished powder.

At the end of the polishing cycle time the hatches are removed from the barrels and the barrels rotated to a point where the hatch openings will allow the powder to run out of the barrels into two chutes.

The chute outlets are seen in this photo. The powder being collected in boxes.

**Figure 65.** Swiss powder plant.

**Figure 66.** Another view.

The above photos show the polishing barrels used in the Pouderie D' Aubonne S.A. powder plant in Switzerland.

In comparing the polishing barrels at the S/A Pernambuco Powder Factory to those used in the Swiss plant keep in mind that the Swiss plant specializes in small batches of very high quality powder while the plant in Brazil produced very large amounts of what might be described as common powder.

The polishing of the powder produces a good bit of powder dust due to the wearing away of sharp grain edges during the time the powder is tumbling in the barrel. If this dust clings to the powder grains and is allowed to remain on the grains' surfaces it will yield a powder that is dirty to handle in the field and add to bore fouling in the gun.

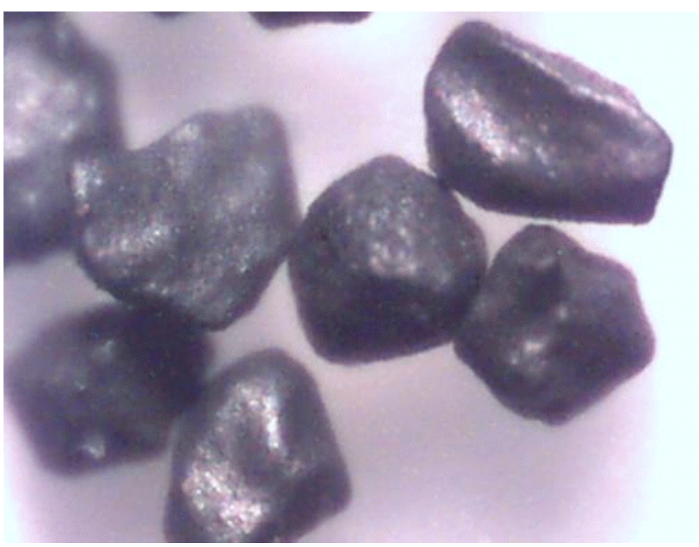


**Figure 67.** 1998 production Elephant 2Fg.

Here we have a microscope photo of Some 1998 production Elephant 2Fg. In this photo the grain edges appear to be a bit "fuzzy". For want of a better term.

When viewed at a magnification of 200X the dust on the surfaces of the grains is more visible.

This production run of Elephant was noted for being dirty to handle.

In the 1999 production run of Elephant for the U.S. they added squares of cotton muslin to the powder in the polishing barrels. As the powder grains rubbed on the cloth during polishing the fine dust would be removed by the fabric and held within the weave of the fabric.

This process was something of an adaptation of the old powder "reel" seen in publications on the manufacture of black powder in England at the Royal Gunpowder Factory, Waltham Abbey.

At Waltham Abbey the powder from the corning mill was placed in a device known as a "reel". This looked like a barrel made from cloth. The powder was added to the reel and as it flowed over the fabric the dust would be removed from the surfaces of the grains of powder. Different types of powder called for different cloths to be used in the reel.

Over the past few years there have been a number of black powder shooters commenting on dirty lots of various brands of black powder on the Internet message boards. The exception being the Swiss black powder. No complaints on dirty powder lot.

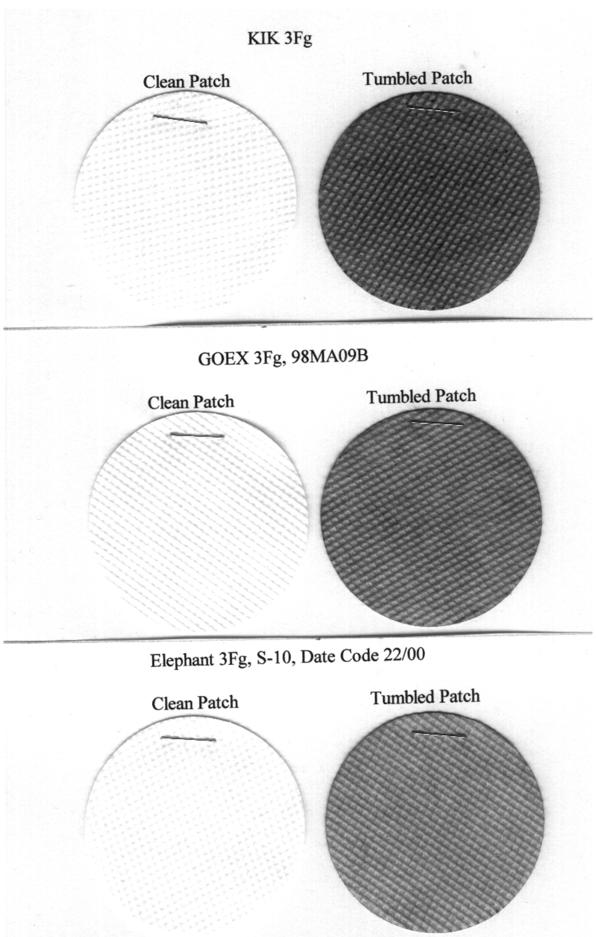



**Figure 68.** Check for dirt.

Here we have something of a comparison between three brands of black powder dating to the year 2000.

This is something of an adaptation of the S/A Pernambuco Powder Factory's cloths in the polishing barrel powder cleaning method.

Commercial cleaning patches were used in this work. Equal weights of each brand of powder were placed in peanut butter jars. A clean cloth patch went into each jar.

The jars were then rolled on the floor for 5 minutes. Then the patches were removed, mounted on card stock and scanned into the computer.

Most of the discoloration seen on the patches is graphite removed from the powder grains. It is a combination of graphite and powder dust that the shooter sees as "dirty" powder.