S/A Pernambuco Powder Factory

Recife - Pernambuco - Brazil

The Final Years, 1992 to 2001

SOCIEDADE ANONYMA
PERNAMBUCO POWDER FACTORY
SUCESSORA DE HERMAN LUNDGREN
CASA FUNDADA EM 1866

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STO. ANTONIO - RECIFE
CAIXA POSTAL Nº 63
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By
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Founding

The S/A Pernambuco Powder Factory was established by Herman Lundgren, a Swedish immigrant, in 1866. This was the first black powder manufacturing plant to operate in Brazil.

Herman Lundgren had the powder plant built by an English contractor following the most up to date manufacturing methods in use in England at that time. The plant property encompassed 470 hectares about 20 kilometers outside the city of Recife in Brazil. At its height, the working portion of the property covered approximately 160,000 square feet with 23,000 feet of railroad track between the various buildings. Typical for a large European designed black powder manufacturing facility of the day, the plant was built around the use of 9 German designed and constructed 5-ton wheel mills.

Entry Into The U.S. Market

In September 1992 a container of Elephant brand black powder arrived in the United States. A 33,000 pound container brought into the U.S. through Petro-Explo, Inc., Arlington, Texas. At that time, Petro-Explo, Inc. set up 5 distributors for this black powder. Petro-Explo, Inc. being owned by Oscar Rodes, a Brazilian immigrant to the U.S., and James Kirkland.

Clarksville Gun & Rod, Clarksville, Arkansas Redmond Explosives, Kewanee, Illinois Ladshaw Explosives, Inc., New Braunfels, Texas October Country, Hayden Lake, Idaho Upper Missouri Trading Co., Crofton, Nebraska

In 1991, GOEX, Inc. had an explosion at their Moosic, PA black powder manufacturing plant that killed 3 workers and seriously injured a 4th worker. The plant was out of production for several months as a result. Being the last operating black powder manufacturer in the U.S., the 1991 explosion caused customers to look to possible alternative suppliers from abroad. The German firm of WANO also shipped black powder to the U.S. in 1992 in an attempt to gain a foothold in the U.S. market.

Quantities Imported, 1992 - 2001

1992 - 32,980 pounds.
1993 - 102,397 pounds.
1994 - 235,103 pounds.
1995 - 35,935 pounds.
1996 - 101,647 pounds.
1997 - 309,628 pounds.
1998 - 358,288 pounds.
1999 - 192,256 pounds.
2000 - 353,991 pounds.
2001 - 486,838 pounds.

Explaining the fluctuations.

The jump in poundage between 1993 and 1994 shows the addition of fireworks and fuse powders to the Elephant product line in the U.S.

The drop in poundage for 1995 was the result of a fire and series of explosions at the plant in Brazil that destroyed about 2/3 of the installation. Rebuilding the facility took roughly 7 months, extending into early 1996.

The jump between 1996 and 1997 was the result of another incident at GOEX's Moosic, PA black powder plant where a lightning started fire destroyed the coming house and coming mill. GOEX's Moosic, PA plant being out of production for 6 months as a result.

The 1997 - 1998 data was the result of yet another explosion at GOEX's Moosic, PA plant in June of 1997. An explosion in front of the rebuilt coming house flattened the building. Shortly after the explosion GOEX closed the plant and began to move the plant's machinery to a new facility then being constructed at a site near Minden, Louisiana. The new GOEX facility going into operation in early 1998.

The 1998 thru 2000 data reflects the sale of Elephant black powder to a major military contractor.

The 2001 data shows an attempt to bring up a large amount of powder, from Brazil, to hold the U.S. customers over while the powder plant in Brazil was to be moved to a new location.

The Powder Factory

Grounds.

The actual working portion of the plant property is picturesque with the grounds having been maintained almost as if it were a garden.

An old wheel from a wheel mill forms the center piece in the old office yard. Other pieces of old plant machinery are positioned around the yard.

Figure 3. Wheel mill garden decoration.

The powder cart tracks in the center of the photo are used to convey raw materials or powder in process from one processing building to another. Areas along the sides of the track paths are set up as gardens.

Figure 4. Cart tracks

The powder processing area of the plant is serviced by approximately 23,000 feet of cart rail tracks.

Figure 3. Rail cart tracks leading to a building

Two workers move a cart containing several bags of powder to a processing building.

Figure 4. Plant workers moving a cart of powder.

Note that the two workers are wearing long rubber boots. The reason for the wearing of these boots will be shown in pages dealing with wheel-milling and pressing of the powder.

Figure 5. Wheel mill destroyed by fire/explosion in 1995.

This wheel mill and building stands as a reminder of an accident that occurred at the plant in 1995. A sugar-based explosive composition was being prepared in a small building attached to the charcoal building. The batch of sugar-based composition burst into flames. Embers from the burning building drifted over the black powder processing buildings and started a series of explosions that destroyed about 2/3 of the plant.

Raw Materials (Ingredients) Preparation.

Figure 6. Bags of potassium nitrate

Figure 7. Bags of powdered sulfur.

Potassium nitrate and sulfur are purchased in bagged form. The potassium nitrate being fine crystals and the sulfur as a powder.

From 1992 until about 1996 the S/A Pernambuco Powder Factory purchased a high-purity grade of potassium nitrate produced in Israel by the Haifa Chemical Company. Then a company in Chile began to produce potassium nitrate and it was no longer possible to purchase the Haifa Chemical Company potassium nitrate in South America. The potassium nitrate produced in Chile is a technical grade but none of the impurities are harmful to the powder or the gun in which the powder is used. The bags of potassium nitrate shown in the photograph originated in Chile.

Figure 8. Ingredient preparation building.

In this building the potassium nitrate and sulfur are screened prior to being portioned out for wheel mill batches. The ingredients are hand screened to remove any foreign material larger than a certain screen size and to remove any bits of tramp metal that might have gotten into the material at the source.

After the ingredients have been weighed out into bags for individual wheel mill batches the bags are then stored in this shed prior to being moved to the wheel mills.

Figure 9. Wheel mill batch storage building.

Charcoal Production.

Wood used and preparation of the wood.

Figure 10. Imbauba palm tree.

When the English contractor built the S/A Pernambuco Powder Factory, in 1866, they had selected the wood of the Imbauba palm tree as the local wood of choice. The types of wood that had been traditionally used in England and in Europe were simply not available in Brazil at that time.

The Imbauba tree is a type of palm tree that is common in the tropical regions of the Western Hemisphere. This type of palm is noted for its short, rounded leaves rather than long, narrow leaves as are seen with other types of palm trees.

The Imbauba tree also has medicinal uses in that it produces a sap that acts as an astringent or as a purgative.

The trunk of the Imbauba has a hollow central core that is sometimes home to colonies of large ants that will attempt to defend the tree when someone tries to cut the tree down.

The S/A Pernambuco Powder Factory normally purchased their wood requirements from private independent wood cutters. The tress normally being harvested after 8 to 10 years of growth.

The wood arrives at the plant cut to specified lengths. It is then stacked to dry and age.

During the dry season the wood may be stacked out in the open. During the rainy season it would be stored under a roofed shed without sides.

Figure 11. Wood storage.

This photo shows a section of Imbauba wood.

This wood is very light, resembling a hard balsa wood. The bark is very thin and rich in coloring matter.

The open central core having a thin hard skin and baffles divide the hollow-core into compartments at evenly spaced intervals.

Figure 12. Section of Imbauba wood.

Figure 13. Removing the bark.

Figure 14. Before and after.

Prior to the year 2000 powder production The S/A Pernambuco Powder Factory did not remove the bark from the wood used to make their charcoal.

During the wood charring process the bark quickly chars to a very high fixed carbon content. This will cause the powder to throw bit of glowing carbon when ignited and burned.

Tree bark adds to bore fouling in black powder firearms as the bark is rich in mineral matter.

Removal of the bark adds to the cost of producing a black powder but is necessary if the powder is to compete with powders made from de-barked alder wood charcoal.

Charring of wood.

Figure 15. Wood charring building.

Figure 16. Wood charring cylinder.

The wood is tightly packed in the charring tank and the two halves of the tank seam are "luted" to seal the seam.
Originally the charring would be started by igniting the wood inside the tank through the air vents in the bottom of the tank. That process was changed in the year 2000 to "indirect" heating of the wood. A fire box being built under the tank to raise the temperature of the wood to the point where the charring process would begin and produce its own heat.
The charring tanks have no thermometers or other indicators of internal temperatures during the wood charring process. The charring tank operators judging charring conditions by observing the color of the smoke issuing from tank's vent pipes, along with the volume of smoke produced.

The fixed carbon content of the charcoal is important in the performance of the finished powder. This fixed carbon content being a product of charring time and charring temperature. For a small-arms type of black powder known as a rifle type powder the ideal fixed carbon content of the charcoal is in the range of 72 to 75%. "Under burning" or "over burning" of the wood will have a detrimental (bum rate depressing) effect on the bum rate of the finished powder. Charring to a high fixed carbon content will increase bore fouling in small-arms.
When the charring is complete the tank is cooled and the charcoal removed and placed in air-tight bags. Charcoal fresh from the charring tank is reactive in that contact with air will cause an auto-oxidation of the surfaces of the charcoal. This auto-oxidation process evolves heat. Sometimes enough to cause spontaneous combustion in the charcoal.
Prior to use in the wheel mill, the charcoal is pre-ground in a small wheel mill and then screened to removes large pieces and incompletely charred bits of wood.

Wheel-milling.

Figure 17. A 5.5-ton wheel mill.

Figure 18. Another view.

In 1985, the S/A Pernambuco Powder Factory was refurbished with newly manufactured machinery. This included new wheel mills of a type known as 5-ton mills where each wheel weighs about 5.5 tons. These wheel mills having been built in Germany by Krupp. Normal batch size in one of these mills at this powder factory was about 18 pounds of powder.

The length of time the batch is worked in the wheel mill depends upon the type of powder being made. Generally, longer milling time translates to faster bum rates in the finished powder.

This wheel mill is of the overhead drive type. Figure 18 shows the gear box mounted on the wall above the large ring gear on top of the mill. The large ring gear having a pan underneath to prevent anything from falling into the batch of powder being worked in the mill. Any foreign object falling into the batch while the mill is in operation would be certain to cause an explosion.

This mill is of the "suspended runner" design. The two wheels are supported on a pair of rods attached to the cross-beam above the wheels. These rods are adjustable and will keep the wheels from coming in contact with the mill's bed pan in the event nothing is under the wheels. Should the wheels drop down onto the steel bed pan while they are turning there would most likely be an explosion.

Figure 19. Water pool at the entrance to a wheel mill building.

The S/A Pernambuco Powder Factory stressed worker safety. In Figure 4, Page 4 we saw two production workers pushing a cart load of powder between processing buildings while wearing knee-high rubber boots. Here we see the reason for the wearing of rubber boots.

Whenever the wheel mills are in operation the floor of the mill house is flooded with several inches of water. The outer walls of the structure are diked and a dike is formed around the base of the wheel mill.

At the entrance to the wheel mill house there is a square concrete basin containing several inches of water. The entrance pool will remove any stones or grit that might be adhering to the boots.

Both the entrance pool and the flooded floor act to ground the workers in the unlikely event that the relative humidity would fall to levels where electrostatic spark development would be possible.

The flooded floor also insures high humidity in the building which minimizes moisture loss from the batch of powder being worked in the mill. Were the powder to dry out in the mill it could invite an explosion in the mill.

<u>Powder pressing.</u>

Figure 20. Vertical powder press

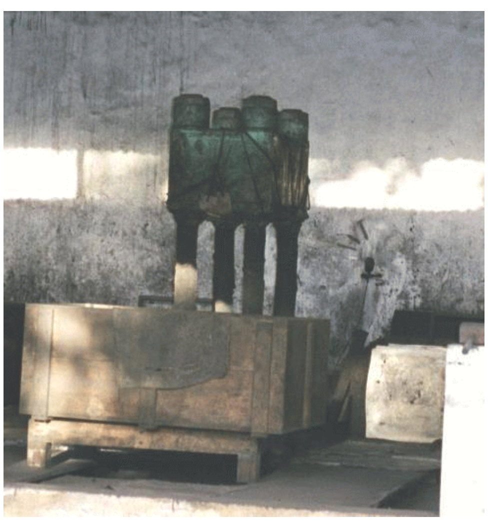

Figure 21. Vertical press, close view.

Figure 20 shows the powder press building with the vertical powder press located in the middle of the building.

Figure 21 is a close view of the vertical powder press. Press plates are stacked against the rear wall to the right of the press.

Powder cake, from the wheel mills, is "laid up" in a uniform thickness between sets of plates. During the pressing operation the mass of powder is both compacted and consolidated. Volume reduction in the powder being pressed is on the order of 40% of the original volume.

Corning.
No photos of the coming mill at the S/A Pernambuco Powder Factory are known to exist.

Screening.
During the coming process the freshly "grained" powder is screened to separate the coming mill product into the specific grain sizes.

Drying.
Drying of the "grained" powder is carried out in rooms heated by steam coils. The grained powder is spread out on cloth covered trays and the trays are then placed in racks.

Figure 22. Wood fired boiler used to generate steam for the drying house.

With wood being plentiful, a wood fired boiler is used to generate the steam used to heat the drying house. Being located in the tropics, this is the only use of steam in the powder plant. This boiler is typical of late 19th century models.

Figure 23. Drying house.

Figure 24. Tray emptying hopper.

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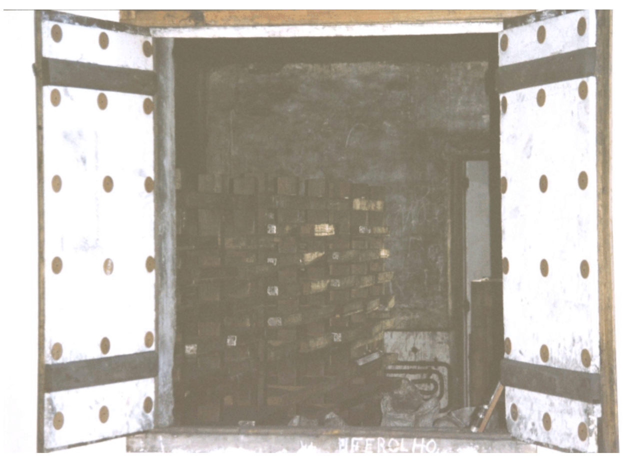


Figure 25. Interior of drying house.

igure 23 shows the exterior of the drying house with the powder cart tracks. The steam supply line, from the boiler, is seen in the left side of the photo where the worker is standing.

Figure 24 shows the hopper used when emptying powder from the drying trays.

Figure 25 shows the interior of the drying house with wooden powder trays in the drying racks.

The steam coils that heat the building are seen in the lower right portion of the photograph.

The drying room temperature may be varied but the room is normally kept at about 130 degrees F. Drying time varies based on the grain size and the time of the year. Dry season versus rainy season.

Polishing, also known as glazing.

Freshly grained (or corned) powder grains have rough surfaces and sharp edges. Unglazed powder has limited use in fireworks applications. For most applications a glazed powder is desired.

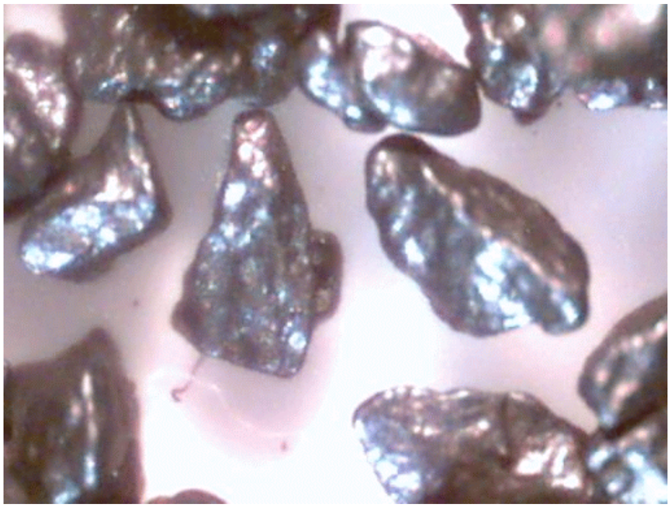


Figure 26. Elephant 2Fg at 60X.

The purpose of polishing powder, or glazing, is to round sharp edges of the grains and to polish the grains' surfaces smooth. During the polishing process the surfaces of the grains are compacted and hardened.
Polished powder will not shed dust as easily as unpolished powder during shipping and handling.

Figure 27. Building housing two polishing barrels.

Well polished powder will be more accurate in a gun when compared to unpolished powder. The extent of grain edge rounding and depth of surface hardening, of the grains, will have a marked effect on flame spreading rates through a charge of powder in a gun.

Each polishing barrel holds about 1,000 pounds of grained powder. The length of time the powder will be tumbled in the barrel is determined by the desired amount of polishing of the grains. In the glazing barrel pictured above, the powder begins with a bulking density of about 0.90 g/cc. In a 6 hour polishing cycle the final bulking density is about 1. 15 g/cc. In an 8 hour cycle the bulking density may be as high as 1.20 g/cc.

Figure 28. A pair of polishing barrels.

Bags of dry grained powder are hoisted to the platform that surrounds the barrels on 3 sides.

Figure 29. Loading hatches.

Each barrel has a removable hatch with a piece of heavy cloth as a hatch seal.
To load the barrels the hatches are removed and the bags of powder are poured into each barrel. The hatches are then placed back over the openings.

Figure 30. Sliding door unloading hatches.

At the end of the polishing cycle the drums are stopped and the hatches removed.
The barrels are then rotated to position the hatches on the bottom.
The polished powder then falls out of the barrels and into hoppers.
The glazed powder is then emptied into bags.

Final screening and cleaning.

During the polishing process dust is created by the breaking away of powder grain edges and surface abrasion. While the surfaces of the grains will be smoothed and polished during the tumbling in the polishing barrel some dust and debris is created. Following a shipment of rather dusty powder in 1998 the S/A Pernambuco Powder Factory began to clean the powder prior to packing and magazine storage. A pair of polishing barrels were set up where the powder would be tumbled with pieces of heavy cotton muslin. The powder grains would rub against the cloth and any dust clinging to the grains would be picked up by the cloth and held in the weave of the fabric. A small screen then removed any larger bits of dust that did not become trapped by the cloth.

Packaging.

Figure 31. Packaging materials.

Packaging materials warehouse.

Powder was originally packaged by hand but a few years before the plant closed packaging machines were installed.

Finished packaged powder storage.

Figure 32. Storage magazines.

Figure 33. Storage magazine entrance.

Finished packaged powder is stored in large concrete magazines to await shipment.

Miscellaneous.

In 1995 the S/A Pernambuco Powder factory was extensively damaged by a fire and series of explosions. Seven factory workers were killed as a result. The rebuilding of the plant took almost 6 months.
The rebuilding program included closed circuit TV monitoring of all powder processing machinery. The machinery being started and stopped from a central control room.

Figure 34. Central control room.

Production workers would service the machinery and then walk to a remote telephone station. The production worker would then report to the control room. A control room operator would then start and stop machinery as required. The closed circuit TV and control, system cost over 1 million dollars when it was installed.

In 1998 the plant began to produce black powder for sale to a U.S. military contractor. The liquid mercur densiometer was replaced by a gas pycnometer. The laboratory upgrade also included a computerized automatic moisture testing balance. Both of these pieces of laboratory equipment having been purchased in the U.S. and then shipped to the plant in Brazil.

Figure 35. Laboratory pycnometer.

Museum.

Figure 36. Bronze bust of the founder, Herman Lundgren.

Figure 37. Various company related artifacts.

Figure 38. Various company related artifacts.

A small office building had been used as a museum to house company artifacts collected over the years. The collection contains antique firearms, several eprouvette powder testing devices, powder cans, etc.

The Powder Produced

When Elephant brand black powder arrived in the United States in 1992 it was produced to specifications that made it less than ideal in certain types of black powder firearms used in this country.

Raw material specifications.

Potassium nitrate.
99.50% purity, minimum.
00.50% maximum moisture content.
00.01% maximum chloride content.
00.50% maximum perchlorate content.
00.50% maximum sulfate content.
Color - White, brilliant.
Consistency, fine crystals.

Sulfur.
99.0% pure.
00. 1 % moisture content.
00.0% acidity.
00. 1% ash.

Charcoal.
05.0% moisture content.
10.0% volatiles.
83.0% fixed carbon, minimum.
02.0% ash.

Graphite.
99.0% fixed carbon, minimum.
01.0% ash, maximum.
100% through a 325 mesh screen.

Powder composition.
75 parts potassium nitrate.
15 parts charcoal.
10 parts sulfur.

Grain sizes.

Fg,
1. 68 - 1.190 mm (10 mesh to 16 mesh)
FFg,
1. 19 - 0.5 90 mm (16 mesh to 3 0 mesh)
FFFg,
0.84 - 0.297 mm (20 mesh to 50 mesh)
FFFFg,
0.42 - 0.149 mm (40 mesh to 100 mesh)

Loading density.
The plant did not operate to a loading density specification at the time. Loading densities on various lots ran from 1. 15 to 1.20 g/cc.

The first shipment(s) of Elephant brand black powder exhibited a burn rate and ballistic strength best described as that of a musket type powder. That means that such a powder would normally be about 10% "weaker" (or slower) than a rifle burn rate powder. GOEX brand black powder then being a rifle burn rate powder.
This musket burn rate Elephant was best suited to the very large caliber muzzle loading guns or those guns using large projectile masses relative to the bore diameter. Bore fouling in the round ball rifles that are .50 caliber, or smaller, was rather heavy. This "dirty burning" property was directly attributable to the very high fixed carbon content of the charcoal used in the preparation of the powder.

When this first shipment of Elephant brand black powder went on sale it was of course compared to GOEX's rifle burn rate powder made with a maple charcoal at a fixed carbon content of about 80%. From 1988 until late 1990, GOEX production was being producing using water drawn from an on-site deep well during a period of drought that was the worst drought in 145 years of weather record keeping. This period of GOEX production represented some of the worst black powder to ever come out of the Moosic, PA black powder plant that had been owned and operated by du Pont prior to 1972. Compared to GOEX's product, this Elephant powder did not look as bad as it would have if compared to GOEX produced during periods of high precipitation in the Moosic, PA area. This drought production powder working its way through the distribution system and in the hands of shooters gave Elephant a bit of time to make the necessary changes in their powder.

Narrative of the years 1993 to 2001

After the first container of Elephant brand black powder arrived in the U.S. in late 1992 it was understood that changes would have to be made in the powder in order to make it competitive with GOEX black powder in the U.S. market. No one, at the time, envisioned the host of problems that would beset the business at the plant and here in the United States. The best way to describe the business is to approach it as a running narrative.

By 1994, Elephant had reduced the fixed carbon content of their charcoal to an average of 78% and by 1995 had lowered the fixed carbon content of their charcoal to the desired 72 to 75% range. This produced a noticeable reduction in the amount of bore fouling produced by Elephant powder in the smaller caliber rifles.

In a.45 caliber flintlock rifle with a 38" long barrel.

WANO 3P
60 grains 1591 fps
1.05 g/cc loading density
WANO 3F
60 grains 1625 fps
1.03 g/cc loading density
Elephant 3F
60 grains 1358 fps
1.15 g/cc loading density (Lot 153/1992)
Elephant 3F
60 grains 1723 fps
1.15 g/cc loading density (Lot 171/1994)
GOEX 3F
60 grains 1708 fps
1.07 g/cc loading density (1995 May lot)

The primary difference between the 1992 Elephant Lot 153 and the 1994 Lot 171 was the reduction in the fixed carbon content of the charcoal from 85% down to 75%. This also made a considerable reduction in bore fouling in the .45 caliber rifle.
When you char wood to increasingly higher fixed carbon levels the rate of combustion of the charcoal is slowed. In the smaller caliber rifles the projectile dwell time, in the bore, is not sufficient to promote complete combustion of the charcoal. As one increases the fixed carbon content of a charcoal its ignition temperature is raised and the rate at which it burns is decreased. Complete combustion of a high-fixed carbon charcoal requires higher gas temperatures behind the projectile and longer projectile dwell times in the bore.
So the 1994 reduction in the fixed carbon content of the charcoal resulted in a powder better suited to the wide range of black powder guns used by shooters in the United States.

A black powder substitute side track, 1994-95.

In mid- 1994, Petro-Explo, Inc. was approached by two men. One of whom claimed to have invented a black powder substitute that would put black powder out of business. It was claimed that this powder could be produced at a cost lower than that of black powder. That this revolutionary powder was perfectly safe to produce and could be processed on existing traditional black powder processing machinery. Suggesting that this powder could be produced by the S/A Pernambuco Powder Factory in Brazil.
Both of the individuals who were then proposing this project had come out of about 10 years of work with the ascorbic acid-based powders that began with Golden Powder. Both having recently left the group then known as Legend Products that was setting up to produce and market Black Canyon Powder.
Petro-Explo, Inc. was told that they had looked at GOEX with a view of having this powder produced by GOEX in their Moosic, PA black powder plant. They approached Petro-Explo, Inc. because they felt that GOEX lacked the necessary level of technical expertise to produce this powder.
One of the men was sent to the S/A Pernambuco Powder Factory, in Brazil, to look that operation over to see if that plant could produce this new powder.
Following the visit to Brazil, the individuals failed to follow through in contacts with Petro-Explo, Inc.

As this evolved through late 1994 and into 1995 it appeared that the contact with Petro-Explo, Inc. and the S/A Pernambuco Powder Factory, in Brazil, was little more than a ruse to pressure GOEX, into picking up the project involving this "new" black powder substitute that would revolutionize the industry and drive black powder out of production.

The management of the S/A Pernambuco Powder Factory showed little enthusiasm for this project. This new black powder substitute was based on the use of fruit sugar (fructose) with potassium nitrate. The S/A Pernambuco Powder Factory was at that time producing a similar composition based on sucrose for use on the end of safety fuses as an igniter.
In 1995, a batch of this sucrose-based igniter composition was being prepared in the plant. A process where the sucrose and potassium nitrate are combined and heated to partially caramelize the sugar. The operator lost control of the heating process. The batch burst into flames. Embers from the burning building drifted over the black powder production area which started fires and initiated explosions of black powder being processed in the plant. The plant was 2/3 destroyed with the loss of 7 lives.
Needless to say, the claim that a sugar-based explosive composition could be made in complete safety was put to rest.
GOEX failed to learn a lesson from this incident and suffered a 2.5 million dollar loss in late 2001 when their Clear Shot building suffered fire and explosions. Clear Shot being their version of what had been proposed to Petro-Explo, Inc. and the S/A Pernambuco Powder Factory in 1994.

Contacts with GOEX Inc.

When the "improved" Elephant powder with the reduced fixed carbon content charcoal began to be used in the U.S. it caught the attention of GOEX, Inc.
When the first container went out into the distribution system in 1993, GOEX purchased a case of it and handed some out to a shooter in the Scranton, PA area who shot it in a .45 caliber flintlock longrifle. He reported that the powder shot slow and dirty, compared to GOEX in the same rifle. Initially GOEX wrote Elephant off as "cheap imported crap". The improved powder caught their eye.
In 1995, the then president of GOEX contacted the manager of the S/A Pernambuco Powder Factory requesting that he make the necessary arrangements for the president of GOEX to visit the S/A Pernambuco Powder Factory.
During the subsequent visit, the president of GOEX suggested a joint venture project where GOEX would import up to 1 million pounds of Elephant brand black powder for sale in the U.S. In other words, to buy Elephant powder directly from the plant in Brazil and ignore the fact that the U.S. firm of Petro-Explo, Inc. was the contractual United States importer for Elephant brand black powder.
The owner and management at the plant in Brazil expressed no interest in this plan. GOEX, Inc. was to repeat this "offer" in 1997, 1998 and 1999.

In 1994, a large black powder plant in South Africa had ceased operations after fire and explosions destroyed most of that plant. The company in South Africa then turned to the S/A Pernambuco Powder Factory to supply them with their black powder requirements. The S/A Pernambuco Powder Factory then had to hire additional employees to handle the expected increase in production and orders for their powder.
The act of one of the new workers was a major factor in the partial destruction of the S/A Pernambuco Powder Factory in 1995 when the worker left an uncovered cart of powder sit out in the open between two powder production buildings. An ember from the "sugar powder" building falling into this cart of powder and the explosion of the cart initiated a series of explosions.

With the S/A Pernambuco Powder Factory out of production during the latter-half of 1995, somebody shipped a large shipment of Chinese-made black powder into South Africa. The plant in Brazil was never able to regain the South African business. This shipment of Chinese made black powder set the stage for what would be major changes in the world market for black powder.

GOEX, Inc. later purchased 5 of the 5-ton wheel mills from the closed South African plant and used them to set up their Minden, LA plant that went into operation in early 1998.

Elephant packaging problems.

The shipments of Elephant black powder made in late 1992, 1993 and early 1994 arrived in tin cans produced in Brazil. The cans were fabricated from good tin plate and the tin plate was subsequently coated with a synthetic polymer solution resin that acted to protect the tin much as with the old lacquered tin plate. The spouts used in these Brazilian-made tin cans consisted of a plastic spout with a plastic snap cap. This design being a copy of a powder can closure used by C&H (ICI) in the 1960's, up until C&H production ceased in 1972.
At this point in time, U.S. black powder shooters had been using GOEX black powder almost exclusively for 20 years. Goex using cans with metal threaded spouts and screw-on caps.
Shooters began to complain that their screw on powder spouts, used with GOEX cans, would not work with the snapcal spouts on Elephant cans. One shooter called Petro-Explo, Inc. telling them that the translucent plastic would allow sunlight to enter the can and thus destroy the powder. Others claimed that the plastic snap cap did not hermetically seal the cans. Of course none had bothered to squeeze a GOEX can and listen to the escaping air produce a faint hissing sound.
So in 1994 Petro-Explo, Inc. purchased threaded spout inserts with plastic screw caps. The problem was that there was nothing to prevent the threaded spout from spinning in the can opening when tiny powder gains of graphite worked under the flange of the spouts.

By 1995-96, Petro-Explo, Inc began to purchase tin cans in the U.S. Tin cans that were fabricated in the same manner as GOEX cans. These American-made tin cans would then be packed in containers being returned to the plant in Brazil.
The problem with these tin cans was that the tin plating was extremely thin. Typical with electroplated tin plate in the U.S. these days. These tin cans rusted during storage in Brazil in their high humidity.
In the year 2000, the S/A Pernambuco Powder Factory, in Brazil, switched to plastic bottles that are produced in Brazil. The plastic bottles being the same size as the tin cans and with a threaded spout molded as part of the bottle. The plastic bottles in this year of production were acceptable. The problem was with the caps. A certain section of the cap had a very thin wall and the cap would separate into two pieces if tightened with too much force.
In the year 200 1, Petro-Explo, Inc. (By now Elephant Black Powder Company) imported twice their normal poundage to carry them through a moving of the powder plant to a new location. The plastic bottle manufacturer in Brazil changed the bottle blowing machinery operating conditions. This was done to increase the number of bottles produced per hour on the bottle blowing machines. As a result, the bottles used for the 2001 production had very thin comers that were prone to shattering if the bottle was dropped or bumped hard at low ambient temperatures.

The plastic bottle manufacturer, in Brazil, was using high density polyethylene (HDPE) to

mold the bottles but a grade with a low molecular weight (>1.0 sp. gr.). The combination of thin-walled comers and low molecular weight HDPE resulted in rather fragile bottles when the bottled powder was stored at temperatures approaching freezing.
The Elephant Black Powder Company was forced to purchase tin cans and repackage almost all of the 2001 shipment of small-arms powder at a cost approaching $100,000.

All of this was the result of the American black powder shooters being unwilling to accept the plastic snap closure cans and the refusal of the Brazilian can company to tool up to make threaded spouts and metal screw caps for their cans.

Formulation changes.

In 1994 and 1995, the S/A Pernambuco Powder Factory reduced the fixed carbon content of their charcoal to give a cleaner burning powder in the smaller caliber guns in use in the U.S.
In 1996, this program of product improvement moved into another phase.
The so-called "standard" formulation calling for 75 parts of potassium nitrate, 15 parts of charcoal and 10 parts of sulfur is really not a "standard" for all types of black powder. Historically, sporting powders were prepared using 77 to 78 parts of potassium nitrate with rifle type powders using 76 to 77 parts of potassium nitrate.

As an experiment, the S/A Pernambuco Powder Factory made a small run of small-arms black powder using 78 parts of potassium nitrate.
The writer then prepared blends using powder made with 75 parts of potassium nitrate and powder at 78 parts of potassium nitrate. These were blended to give samples of powder at 75 parts potassium nitrate, 76 parts, 77 parts and 78 parts. These blends were then tested in a muzzle loading rifle. The idea being to see how much potassium nitrate was required to give the cleanest possible powder combustion with the charcoal being used.
In the shooting there was a very noticeable reduction in perceived bore fouling when going from 75 parts of potassium nitrate to 76 parts. A less noticeable reduction when going from 76 parts of potassium nitrate to 77 parts. Shooting with the powder prepared with 78 parts of potassium nitrate gave a bore fouling containing beads of incompletely reaction potassium nitrate. The resulting bore fouling had a "crunchy" feel when a damp cleaning patch was run down the bore and that were patches were the fouling stuck to the bore as if it had adhesive properties.
Starting with the 1997 production, the formula was changed to 76.5 parts of potassium nitrate with a commensurate adjustment of the amount of charcoal and sulfur in the formulation.

Clean powder technology.

When handling Elephant powder, in the loading of firearms, pouring the powder would sometimes produce visible dust drifting away from the stream of powder. This dust was a combination of very fine powder dust and loose graphite. This had to be addressed after the large shipment into the U.S. in 1998.

When the plant corned the press cake, in the corning mill, the powder would next require screening to separate the corning mill product into the specified grain sizes. The corning process produces a considerable amount of dust that is collected and reworked back into the powder press. Graphite is added to the powder, dusted on, to increase screening rates. After the corned powder is tray dried it must be "polished" in the glazing barrels. As the edges of the powder grains are rounded by the tumbling action of the polishing barrel it will create powder dust. The same is true when surfaces of the grains are smoothed and compacted by friction between the grains rubbing together under considerable pressure. In essence, the grain polishing process may create a considerable amount of dust in the powder. If this dust and debris is not removed from the powder prior to packing the finished powder will be dusty and dirty. This is objectionable to shooters in several ways. Excess graphite makes post-shooting gun cleaning more difficult. Dust and debris in a powder detract from accuracy.

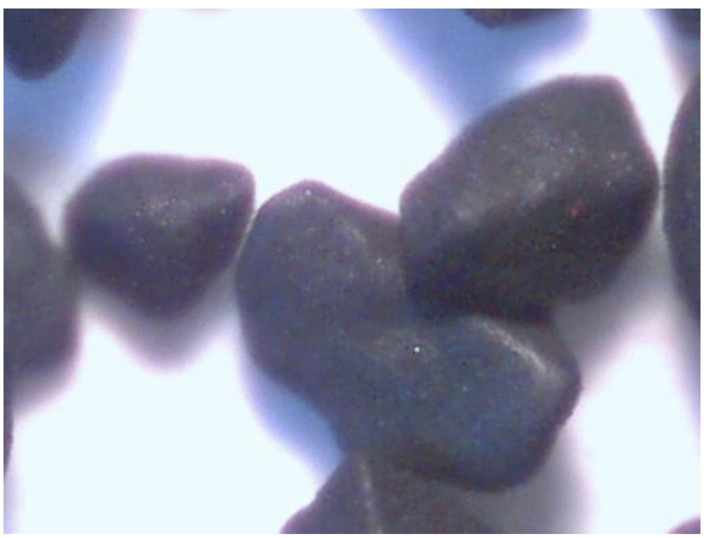
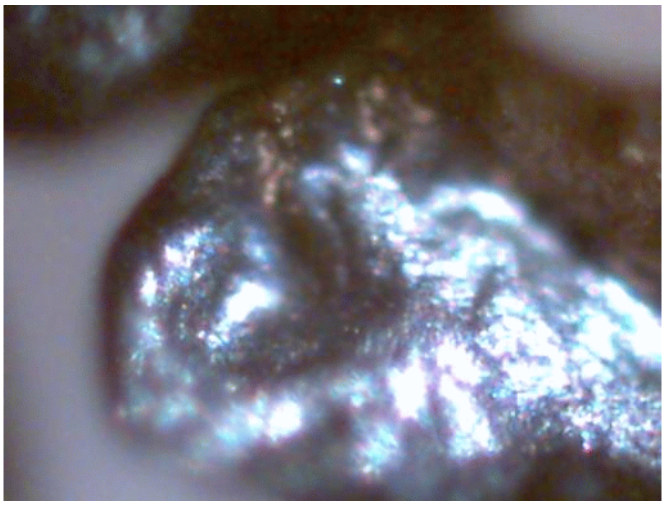


Figure 39. Elephant 2Fg, 1998 at 60X.

While these powder grains show well rounded edges and very smooth surfaces the dull appearance is produced by a thin coating of powder dust created during the polishing process.
A number of shooters would clean such powder by placing it in a cloth tube, such as a long athletic sock, and work the powder around gently in the sock. This rubbing on cloth would remove the coating of dust and trap it within the weave of the cloth. The performance of the powder in the gun would be improved as a result.

For the 1999 production run at the S/A Pernambuco Powder Factory the plant was given suggestions on methods that could be used to clean the powder just prior to the packaging of the powder.
The method selected was to simply place large pieces of heavy cotton cloth into the powder polishing barrels toward the end of the polishing barrel cycle (time).
This was something of an adaptation of a 19th century English method of the final cleaning of black powder. The English had what was known as a reel. This was a barrel-shaped frame with a cloth web suspended within the frame. In essence, a cloth barrel in which the powder was tumbled for a short period of time.



This is a microscope view of a grain of Elephant black powder that had been cloth polished just prior to being packaged. The surfaces being totally free of minute powder dust particles.

Powder processed in this manner comes out exceptionally clean.

Figure 40. Elephant 2Fg, 2001 at 200X.

<u>Production problems that were never corrected.</u>

Ingredient particle size variations in the finished powder was a powder quality issue that was never addressed effectively.
Prior to using their charcoal in the wheel mills they would first crush the charcoal in a small-wheel mill and screen it to remove pieces of incompletely charred wood. The crushed charcoal being screened through a 40 mesh screen. Later changed to an 80 mesh screen.
Certain production runs of powder were noted for scintillation. That term describes large glowing sparks being thrown by the burning powder. In a firearm you will see these glowing bits of charcoal being blown out the muzzle with the spent propelling gases.

Du Pont, GOEX and ICI (C&H) prepared charcoal and sulfur as a mixture. This mixture was then placed in a large ball mill. Up to 2,000 pounds of this mixture would be ball-milled. If the powder being made called for an ingredient ratio of 75 - 15 - 10, the mixture of charcoal and sulfur being ball milled would be 60% charcoal and 40% sulfur. The mixture would be ball-milled for up to 12 hours. Then removed from the ball mill and screened prior to being portioned out for powder batches in the wheel mill.
This ball-milling of the charcoal and sulfur greatly reduced their respective particle sizes. In addition, ball-milling time was set to give a consistent particle size. With ball-milling, a point is reached in ball-milling time where no additional particle size reduction does not occur. This is a major factor in producing batch to batch consistency in the burn rate of the wheel mill batches.

With the method used by the S/A Pernambuco Powder Factory, all ingredient particle size reduction was carried out in the wheel mills. Variations in the particle size of the charcoal going into the wheel mill would be reflected in the particle size of the charcoal in finished wheel mill batches.

This was invested using 200 mesh stainless steel screening and samples of the finished powder. Selected powder lots would be broken down in warm water with a bit of liquid dish soap added as a wetting agent. This slurry would be poured into a cone made from 200 mesh stainless steel screening. The slurry would then be washed through the screen with running tap water. Material not passing through the screen would be dried and weighed.
For best results there should be no particles of charcoal remaining on the 200 mesh screen. Some lots of powder showed some very large particles of charcoal retained on the screen.

So this inability to control charcoal particle size throughout the powder-making process introduced a variable that was then reflected in burn rate variability in the finished batches of powder. It was an issue that should have been addressed promptly but never was.

Considering the numerous production and distributions, Elephant brand black powder was well accepted in the U.S. market. Various Internet black powder related message boards ran surveys as to which brand of black powder the message group shooters preferred. In the year 2000, the results showed 1 Elephant brand shooter for every 2 Goex shooters.
When Elephant brand was good powder it was pleasant to shoot. With some production runs the powder would work but the shooter had to work harder to get it to work well.

When Elephant brand black powder first arrived in the hands of the U.S. black powder shooters in 1993 it received mixed reviews. Throughout the entire period while Elephant was available it had a reputation for accuracy. An inherent accuracy that was at least as good as that with Goex and mainly better than Goex.
But being a musket burn rate black powder, until 1999 production arrived, it worked best in the larger bores or with heavy projectiles. In the smaller bores, and with low mass projectiles, it earned a reputation for heavy bore fouling. As the plant revised their charcoal and adjusted the potassium nitrate content of the powder the bore fouling was reduced. The change to a rifle burn rate in 1999 production further reduced bore fouling with the powder.

U.S. black powder shooters judge the fouling properties of a black powder through visual observations of the post-firing condition of the bore and felt resistance when cleaning between shots or reloading without cleaning. In this respect the U.S. black powder shooters were woefully ignorant of the nature of black powder and the post-firing residue it leaves behind in the bore.
A method was devised to place numerical values on the issue of bore fouling after firing a shot from the gun.

In a .45 caliber flintlock rifle with a working barrel length of 31 inches.

1998 production, 3.8% of the original charge weight as recovered bore fouling.
1999 production, 2.3% of the original charge weight as recovered bore fouling.
2000 production, 2.5% of the original charge weight as recovered bore fouling.

The difference of 0.2% seen in the 1999 versus the 2000 data is within the test method variation. The drop of 1.5% between 1998 and 1999 is significant in that it reflects changes in the manufacture of the powder that were designed to reduce bore fouling. The 1998 lots were dirty and dusty. The 1999 lots were produced using the “clean powder technology”. The burn rate changed from that of a musket type powder, in the 1998 production, to a rifle burn rate in the 1999 production. Increasing the burn rate in the powder helps to reduce bore fouling in the smaller calibers such as the .45 caliber patched ball rifle.

In this testing, 1999 through 2001 Elephant production was tested against GOEX, KIK and WANO black powder. The data were all within 0.5% of each other on any given day of shooting.

Factors leading to the closure of the S/A Pernambuco Powder Factory.

The events that lead up to the closure of the powder factory in Sept. 2001 were of a cumulative nature. The decision to cease operations came about as the result of a series of events that began in 1995.

In 1995 there was the fire and explosions that destroyed a major portion of the plant. The plant was then out of production for 6 months while the plant was being rebuilt. Part of the rebuilding program involved the installation of the closed-circuit TV monitoring and control system. The cost for this system was around $1.5 million.
The plant had then just begun to produce powder for the South African market. These would be large powder orders. These orders being part of the justification for the cost of rebuilding the plant to far higher safety standards. With the plant out of production the Chinese moved into the South African market which cut Elephant out of that market.

This point in time was also the beginning of a decline in domestic powder sales in Brazil. While exports of powder to the U.S. had been steadily increasing, the domestic market went "soft" and exports to countries other than the U.S. failed to materialize or simply stopped.

The plant ran on a reduced scale after that point in time.

In the year 2000, Brazil had some unusual weather. The annual rainy season was exceptionally heavy in the Recife area. Normally the heaviest rains would fall farther to the North. In 2000, the heaviest rains shifted South. This caused extensive flooding in the area around Recife. As with most old powder plants, the S/A Pernambuco Powder Factory was built along a river that in the 19th century would supply water and a transportation route. Twice during the year 2000 rainy season the plant was subjected to flooding that would put it out of production for up to a month. Once the flood waters would recede it would be necessary to remove the mud and debris left by the receding flood waters. The whole thing being rather costly to the plant owner and it happened twice in the same year.
In essence, the decline in annual output and the inability to completely recover the 1995 rebuilding costs placed the owner's investment in a precarious position. In addition, the world economy was beginning to go "soft". So the idea of a turn around in the plant's fortunes was growing even more remote.

The powder plant was built in 1866 in a location that was then considered to be removed from the city of Recife. In the 135 years since the construction of the plant the city of Recife has grown. The city now grows ever closer to the powder plant. The river-front property is now worth a considerable sum of money as building lots.
The growth of the city of Recife recently began to impact on the powder plant in that it created transportation problems. To ship powder from the plant to a waiting ship the powder must be hauled about 50 miles down the coast of Brazil to a port set up specifically for the handling of dangerous cargos.

So the owner of the S/A Pernambuco Powder Factory felt it was time for him to withdraw from the black powder manufacturing business before the business became a drain on his business investments.
The business and machinery were then put up for sale while the owner would keep the ground on which the plant had long operated on.

In September of 2001 the plant was shut down due to a lack of orders for powder. By November of 2001, the owner of the business felt that it was time to get out of the black powder business. The business and the plant's machinery was put up for sale. The owner would retain ownership of the land on which the plant had been built.

The powder plant is located about 20 kilometers outside the city of Recife. As the city of Recife grows it had become increasingly more difficult to ship powder from the plant. Especially export shipments. The docks in Recife would not allow the handling of explosives. In order to ship powder out of Brazil it became necessary to transport the loaded containers, by truck, to a port about 50 kilometers south of Recife. To a port dedicated to the handling of dangerous cargoes. There, to be loaded onto a waiting ship.

By December of 2001 an investor expressed interest in purchasing the business and the machinery. With the intent of constructing a new facility near the port to the south of Recife. The concept was to construct a new plant and then move the machinery from the idled plant to the new plant. Employment at the new plant would then be offered to the former powder plant employees.
It is now a little over a year since the S/A Pernambuco Powder Factory was closed. At this point in time there is no movement relative to the construction of a new facility. This raises questions on the future of the business.

From a historical perspective. Powder plants have been moved in the past. Simply transferring the machinery from one site to another does not insure that the powder produced at the new facility will be of the same “quality” as that which had been produced at the dismantled plant.
Trained workers are an important part of what a shooter perceives as “quality” in a small-arms black powder. There is little actual “science” in the manufacturing process with black powder. The powder plant workers must rely on experience gained through several years experience in determining how they will handle the powder at their point in the process. To start up a new plant with a new staff of production workers is a difficult process at best.

ICI shut down the old C&H black powder plant in Scotland in 1972. The machinery then having been shipped off to a facility in what was then West Germany. The powder that then came out of this West German plant did not compare with the powder that had been produced on the same machinery in Scotland. ICI concluded that while you may be able to transfer the black powder manufacturing machinery to another location you cannot simply transfer the “technology”.

As this is being written the probability that the plant will be moved and restarted grows increasingly remote. That once a new plant is started it could immediately begin producing small-arms black powder suitable for the U.S. market is even more remote.

December, 2007.

The above paragraph was written in 2002. At that time a wealthy young man in Brazil was attempting to purchase the machinery and the Elephant trademark from the owner of the closed S/A Pernambuco Powder Factory. While the owner was willing to sell the machinery he did not wish to sell the trademark that had been in his family since 1866. The prospective buyer wanted the Elephant name and trademark. This is the way matters stood in 2002.

Then there was a rumor in the industry that the machinery from the closed S/A Pernambuco Powder Factory had been sold and was moved to a new plant built about 50 miles to the south of Recife on the coast of Pernambuco province in Brazil. A port constructed by the government of Brazil specifically designed to handle hazardous material cargoes.

In April of 2004 the NRA held its annual convention at Pittsburg, PA. A company known as Diamondback Chemical Company had a booth set up at the event. On their table were questioners for black powder shooters. Simply asking the respondent if they would purchase foreign made black powder. It was clear that this black powder was to be produced in Brazil.

The author had a long talk with the representatives from Diamondback Chemical Company describing the problems encountered with the quality of the black powder produced by the defunct S/A Pernambuco Powder Factory.
Then nothing more was heard on this.

In April of 2006 a 25 thousand pound container of black powder arrived in the U.S. from Brazil. Diamondback Chemical Company operating out of a facility located near Tamaqua, PA. Diamondback Chemical Company is a subsidiary of Copperhead Chemical Company. The facility at Tamaqua, PA had previously been owned and operated by Atlas powder who manufactured dynamite at the facility. After Atlas Powder ceased operations at this facility is was taken over by ICI Explosives and then in 1997 sold to Copperhead Chemical. Copperhead Chemical Company until a few years ago produced the IMR smokeless powders. The IMR smokeless business having been purchased from duPont and sold to the Hodgdon Powder Company. This gave Copperhead Chemical Company a good deal of money to play with and someone thought black powder importing might be a good business to get into. They did almost no market research and might be in for a rude awakening as to the present state of the business. None of this April 2006 shipment of black powder from Brazil was released to the public for testing or use. One may only surmise that this shipment simply did not come up to the required standards. The business had changed since the S/A Pernambuco Powder Factory had closed in 2001. The high point in powder quality out of S/A Pernambuco Powder Factory was in 1999. GOEX was having raw material problems at that time. Once GOEX got their raw material problems in hand the quality of their powder improved. The best produced by S/A Pernambuco Powder Factory in 1999 would no longer be competitive against GOEX in the U.S. market after GOEX improved their powders.

Then in July of 2007 another container of black powder arrived from Brazil. A container holding 24,500 pounds.
This was handed out for independent testing.

Can markings:

Made by Elephant Industria Quimica, LTDA
Barreiras, Pernambuco, Brazil

Imported by Diamondback Chemical Co.
Tamaqua, Pennsylvania, USA

Two representatives from Diamondback Chemical Company had given a one-pound can of 3Fg black powder to a local black powder gunshop for testing and possible orders for more powder. The one-pound sample being handed to the author for testing. Representatives from Diamondback and Copperhead then began to follow the testing by the author.
The new powder plant in Brazil had told Diamondback Chemical Company that this powder out of the new plant was improved in several ways over what had been produced at the old plant. Testing of the powder showed that it was a close match to the 1999 production out of the old S/A Pernambuco Powder Factory. In the gun it was slower that GOEX black powder while bore fouling characteristics were equal. Diamondback Chemical Company will price this powder at the same price as GOEX. Forgetting that one of the big attractions for the old Elephant black powder was its lower price, compared to the price of GOEX.

One noticeable thing in the "new Elephant" was the amount of oversized charcoal particles. The old and new plant in Brazil breaks down charcoal in a small wheel mill. Not in a ball mill as is done by some of the other black powder manufacturers. This is looked at by breaking down a weighed amount of powder in warm water and then washing the slurry through a 200 mesh stainless steel screen. Drying the material remaining on the screen and then calculating it as a percentage of the total charcoal in the powder. In addition, looking at the size and appearance of the oversize particles under a microscope. In the case of this 2007 shipment of new Elephant it was found that 13% of the total charcoal was found as greater than 200 mesh in size. This is objectionable in the gun from the point that these particles will be ejected from the muzzle of the gun as bright orange sparks. In GOEX one will find about 4 to 5% of the charcoal as plus 200 mesh in size but not in particles as large as those seen in the new Elephant. This charcoal particle size problem had been a continual problem with the old Elephant that was never addressed effectively at the S/A Pernambuco Powder Factory.