

# PURIFICATION OF ARSENIC TRIOXIDE USING HIGH TEMPERATURE GAS FILTRATION

by

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## INTRODUCTION

The Yellowknife Division of Giant Yellowknife Mines Limited is located about four miles north of the city of Yellowknife, capital of the Northwest Territories, Canada. Yellowknife is a city of 12,000 located on the north shore of Great Slave Lake at latitude 62°, about 275 miles south of the Arctic Circle and 800 air miles north of Edmonton, Alberta, Canada.

Mining operations at Giant began in 1948 but prior to this, metallurgical testwork showed that the complex ore would require special treatment to liberate the gold from the arsenopyrite with which it was intimately associated. In those days, the most practical treatment for refractory sulphide ores was autogenous roasting of the concentrate followed by calcine cyanidation. This was the process that was selected for Giant and, though equipment modifications have been made over the years, this is still the preferred method.

Roasting of arsenopyrite concentrates results in the formation of impure arsenic trioxide vapours which are subsequently condensed and captured as a byproduct in fabric filters. Arsenic bearing dust from roaster exhaust gas has been stored in underground chambers at Giant since 1951 and today there are some 214,000 tons of dust in storage, containing approximately 127,000 oz. Au and 166,000 tons arsenic trioxide.

Using current arsenic trioxide and gold prices, it is evident that the baghouse dust reserves have a considerable revenue potential. In recent years, other benefits of reclaiming baghouse dust from underground storage have been recognized and a number of activities have been undertaken that will soon permit Giant to take advantage of its particularly favourable position as a major source of arsenic trioxide.

Some benefits that are expected from the reclaim program, despite the current soft market conditions, are as follows:

- Sale of arsenic trioxide.
- Sale of gold contained in baghouse dust.
- Sale of gold contained in crown pillars in area surrounding arsenic storage chambers.
- Eliminate necessity of providing storage for baghouse dust.

Eliminate what could be a long term environmental concern and an expensive abandonment project.

During the early 1980's, a serious effort was made to market a portion of the crude arsenic trioxide being produced at the time and a surface storage and bulk loading facility was built for the purpose. However, it was found that the product was incompatible with the client's process and shipments were stopped after a period of intermittent operation.

Prior to this, there was a major testing program done in 1979-80 to determine a practical means of upgrading the product to render it marketable and to recover the gold contained in the resulting residue. The testing program was quite comprehensive and involved pilot testing of the hot water leach/crystallization process that was subsequently installed at what is now the Nerco Con Mine, as well as a series of fuming/condensation tests in lab scale done by Falconbridge Metallurgical Laboratory.

Both methods worked quite well on currently produced Giant baghouse dust, achieving product grades exceeding 99.4%  $As_2O_3$  in the case of HWL and 99.7% using the fuming method.

## MARKETING

Naturally the wood preservative and pesticide markets, which are by far the largest users of  $As_2O_3$ , cannot absorb 166,000 tons of  $As_2O_3$  all at once, but marketing studies indicate that it is possible to enter the market at a production rate of 7,000 stpy, increasing to 16,000 stpy as market conditions permit.

Increasing plant throughput from 7,000 to 16,000 stpy will be achieved through redesign and replacement of undersized equipment as production rates increase and by modularizing plant design. The fuming reactor will be capable of treating various grades of feedstock at rates ranging from 20 to 45 stpd.

Before detailed planning of the process plant could begin, a marketing study to determine optimum production rates and to estimate project cash flow was necessary. Giant retained a marketing consultant with many years of experience in arsenic trioxide marketing and a comprehensive study was conducted. Terms of reference for the study were:

- a) List of producers and capacities
- b) List of major consumers and consumption quantities
- c) Price history in USA and 5 year forecast for feasibility purposes
- d) Delivered customers works price analysis
- e) Market specifications
- f) Transportation methodologies and costing
- g) F.O.B. Giant price determinations
- h) North American consumption history and 5 year projection of Giant's sales volumes for feasibility purposes.

Armed with information provided by the study, a detailed mining plan was produced that will permit Giant to most effectively reclaim dust from underground storage and permit access to the valuable crown pillar ore.

#### PURIFICATION PROCESS DEVELOPMENT

Development of the fuming process for purification of baghouse dust has been the result of a thorough examination of alternative processes and market conditions. Giant has tested the hot water leach process and is familiar with the ammonia leach process used by at least one chemical manufacturer. It is Giant's opinion that, in most respects, the fuming process is superior; for example capital and operating costs are lower, operation is simplified, overall recoveries are better and gold bearing residues can be treated without fouling conventional leach circuits.

#### FUMING PROCESS

In 1980, Giant approached Falconbridge Metallurgical Labs to conduct laboratory scale testwork to investigate the technical feasibility of fuming of baghouse dust to produce a high purity arsenic trioxide product.

A sample of baghouse dust of the following composition was provided for the test.

Wt%			
As <sub>2</sub> O <sub>3</sub>	Fe	SiO <sub>2</sub>	Sb
81.8	1.8	3.4	0.14

Some conclusions determined from the testwork were as follows:

1. The fuming of arsenious oxide from Giant Yellowknife baghouse dust in a fluid bed reactor appears to be technically feasible
2. Product purity is excellent at 99.7% As<sub>2</sub>O<sub>3</sub>. Fe ranged from 0.006 to 0.009%, Zn <0.001 to 0.002% and Sb 0.06%
3. The fluidizer was quite clean after each test showing no signs of deposits in and around the dust entry point. The sand bed was virtually the same after each run as at the beginning with no sign of ash fusing to the bed.

#### RESEARCH PRODUCTIVITY COUNCIL PILOT FUMING TEST

Following the FML testing, a rudimentary design and flowsheet for a 100 lb/hr pilot plant was produced. This design formed the basis for pilot testing performed by RPC during the summer of 1988.

Research and Productivity Council is a commercial testing facility in Fredericton, New Brunswick that was set up in 1962 and originally funded by the provincial government. It now operates independently and recovers operating costs by charging fees for its

work. RPC has developed an expertise in fluid bed technology over the past 15 years and now has a number of various sized fluid bed reactors available for pilot testing. In addition to roasting of complex base metal sulphides, RPC has examined a number of other fluid bed processes including removal of arsenic from copper concentrates and roasting of antimony sulphide to produce an upgraded antimony oxide product.

In August of 1987, Giant examined the feasibility of building and staffing a pilot plant on site. It quickly became apparent that a pilot plant with the degree of sophistication required would be very expensive. It would also be difficult to staff with full time professionals. In considering alternatives, RPC was contacted and discussions indicated that pilot testing in RPC's facility would be preferable to building and operating a plant on site. Details for doing the testwork were ironed out and approximately 12 tons of baghouse dust collected from various locations underground were sent to New Brunswick as feed for the plant.

#### PILOT PLANT DESCRIPTION

One of the fluosolids reactors at RPC, a 6" dia. model, was just the right size for the test program, capable of operating at a 1.2 ft/sec space velocity and a 20 - 30 lb/hr feed rate. Major modifications to the plant were required however and as a consequence, a rather lengthy delay to permit design, fabrication and installation of the specialized equipment was experienced.

Eventually plant modifications were complete and shakedown testing began in May, 1988. The plant equipment consisted of the following:

- A 1 ton feed bin equipped with a vibrating bottom and a variable speed screw feeder
- A fluosolids reactor with a 6" dia X 60" deep bed section and a 8" dia. X 96" freeboard. A selection of bed overflow heights was available
- A propane burner to provide a hot, relatively inert gas stream to the windbox of the reactor
- A hot baghouse equipped with 3M "Nextel" bags capable of operating at temperatures up to 1250°F.
- A condenser consisting of a S.S. cylinder through which the hot gas was introduced axially at one end, blending with cold air injected tangentially at several points along the length of the cylinder
- A cold baghouse of conventional design
- A rotary vacuum blower downstream of the baghouse
- A wet gas scrubber using ferric sulphate solution as the scrubbing medium
- Pressure and temperature sensors throughout the system.

FUMING PROCESS PILOT PLANT RESULTS

Operation of the pilot plant was very successful, product grades exceeding 99.5%  $As_2O_3$  being consistently achieved regardless of feed grade. Arsenic recoveries ranged from 99.6 to 99.9% with arsenic trioxide concentrations in the hot baghouse residue ranging from 1% to 5%. After some initial shakedown problems with hot baghouse leaks, reactor feed line plugging and accretions of arsenic forming in the condenser, the plant proved to be very flexible and forgiving, permitting a wide range of operating conditions with few circuit upsets.

FUMING PROCESS DESCRIPTION

The flowsheet that has been developed as a result of FML laboratory testing and RPC's pilot test is quite simple, the key component being the hot baghouse in which a highly efficient vapour/solids separation takes place.

Crude baghouse dust, either from current production or from underground storage, is fed dry into the freeboard of the fuming reactor via a conveyor belt and slinger feeder. Feedrate can vary from 25 to 50 lbs/min without equipment modification.

The fluid bed fuming reactor consists of a firing chamber producing combustion gases at 1850°F by burning propane introduced via the tuyeres into the sand bed. The hot combustion gases serve as a fluidizing medium and a heat carrier to supply the necessary heat for fuming. The temperature in the fluid bed is maintained in the range of 800 to 900°F by modulating the feed input.

The flue gases leaving the fluidizer pass through a cyclone to recycle the sand fluid bed media and then to a baghouse equipped with heat resistant bags to capture the fine residue. The purified gas containing the arsenic oxide vapours are cooled by direct contact with ambient air of sufficient quantity to cool the gases to 220°F and condense the arsenic trioxide. The condenser is an air wiper consisting of a cylindrical chamber receiving the cooling air axially on one end and being fed with hot gas tangentially at two sides of the condenser. The cooled gases carrying the solid arsenic trioxide pass through a second baghouse to collect the dust, while the clean gases are exhausted to the stack. The purified arsenic trioxide is then removed to the pelletizing plant for further processing and finally to the product silo for delivery to market.

The fine dust collected in the hot baghouse is removed and directed to an existing mill cyanidation circuit for gold recovery. Since the quantity of this dust is normally quite small, only intermittent dumping is required.

GOLD RECOVERY

The residue collected in the hot baghouse contains at least 99% of the gold originally contained in the dust, along with particulates of iron, silica, etc.. The weight of residue collected is inversely proportional to the  $As_2O_3$  concentration in the baghouse dust, which can vary from <60% to >90%. Gold concentrations in the residue can range from 1.5 to 6.0 oz./ton and is processed in the existing Cottrell dust CIL circuit without further treatment.

Testwork on gold bearing residues from the HWL pilot plant yielded recoveries of approximately 85% but these should not be directly compared with what recoveries might be expected from fuming plant residues. Gold recovery was not included in the FML lab scale fuming testwork but RPC pilot testwork indicates that recoveries in the high 80's can be expected.

SHIPPING

The largest markets for the product (which will be marketed as WAROX, an acronym for White Arsenic Oxide) are in the southeastern United States, and to deliver large quantities of product to these locations, shipping costs are a major consideration.

Upon investigating various shipping alternatives, it became clear that bulk rail shipments are the most economical alternative. Not all customers are set up to receive rail shipments but most of the large plants can do so.

For this reason, Giant has included a truck to rail transfer facility in the arsenic reclaim project. Ideally, the transfer should take place as close to the railhead as possible and for Giant, this location is near the community of Enterprise, Northwest Territories, about 280 miles from Yellowknife. A drum packaging plant has also been included in the design to serve customers not prepared to take delivery of bulk shipments.

