

Interoffice  
Memorandum



Royal Oak  
Mines Inc.

To:

Seena -

CC:

562 235 5100

Re:

13 pages - incl cover.

From:

Ken Morton -

Date:

May 26 '99

Seena -

I've sent you an e-mail re  
the RPC testwork. This is  
some work done by Ron Hatch  
concerning blending UG dust  
with current production dust.

Regards -

Ken

PRELIMINARY

Alternate Process Flowsheet

For WAROX Production

Prepared for

Giant Yellowknife Mines Limited

June 18, 1990

W.R. Hatch

## Introduction

Development has continued at Giant Yellowknife Mines on a process for production of a marketable white arsenious oxide (WAROX). Pilot plant work at Research and Productivity Council (RPC) in New Brunswick identified the major parameters of the process for a separate WAROX plant. Preliminary engineering was completed at Fenco Engineers Inc, including a capital cost estimate for the production of 7000 tonnes/yr of WAROX.

The process involved feeding current and underground crude  $\text{As}_2\text{O}_3$  to a fluosolids reactor operating at  $450^\circ\text{C}$  to sublime the arsenic. Inert impurities and gold were collected on a high temperature filter. Cold air was added to cool the gas stream to  $110^\circ\text{C}$  and condense a purified arsenic. This final WAROX product was collected in a cold baghouse and compacted for shipment.

Final tests at RPC used sintered metal stainless steel filters for hot gas filtration at  $450^\circ\text{C}$ . Additional tests were required, and a pilot plant is currently under construction to further test hot gas filtration. Concepts regarding antimony elimination and  $\text{As}_2\text{O}_3$  particle size growth are also being evaluated.

Consideration is also being given to the purification of arsenic within the existing gas cleaning plant. Replacement of the existing cottrell with sintered metal filters would result in a marketable WAROX product. The addition of crude  $\text{As}_2\text{O}_3$  from underground would give the projected 7000 tonnes per year of WAROX. A process is described in this report incorporating WAROX production into the existing plant. Pilot plant tests are required to demonstrate that a pure product can be produced and to obtain engineering data for sizing and costing a full scale plant, modifying the existing roaster off-gas system.

## General Process Description

The attached flowsheet shows major equipment and flows for the process which is based on the production of 7000 tonnes/yr of WAROX product. This is derived from two sources, (1) current roaster off-gas arsenious oxide ( $\text{As}_4\text{O}_6$ ) and (2) arsenic from underground stockpile material.

The crude  $\text{As}_2\text{O}_3$  is fed into the hot roaster off-gas in a fluosolids sublimator. Available heat in the gas stream is used to sublime arsenic with a resultant temperature drop from  $430^\circ\text{C}$  to  $370^\circ\text{C}$ . The gas stream, enriched in  $\text{As}_4\text{O}_6$  and reduced in volume flow is passed through a hot filter to remove  $\text{Fe}_2\text{O}_3$  and inert solids. The filter off-gas is mixed with ambient air to obtain condensation of the arsenic at  $110^\circ\text{C}$ . High purity  $\text{As}_2\text{O}_3$  is collected in a baghouse (existing) and discharged to a briquetting and flaking process. Final WAROX product is drummed for shipment.

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Features of the proposed process include:

1. Utilization of roaster off-gas heat to sublime the crude  $\text{As}_2\text{O}_3$ .
2. Reduced volumetric flows in the off-gas system as follows:

	<u>Current ACFM</u>	<u>Proposed ACFM</u>
Hot filtration (ESP)	8,700	7,970
Cooling Air (20° C)	26,160	10,514
Baghouse/stack (110° C)	35,000	18,446

3. Utilization of existing fan, condenser and baghouse for WAROX production.
4. Flexibility in that treatment of crude  $\text{As}_2\text{O}_3$  can be shut off and downstream cooling air adjusted to accommodate the higher temperature.
5. Increased concentration of  $\text{As}_4\text{O}_6$  and  $\text{SO}_2$  in the gas streams. The effect of this in terms of  $\text{As}_2\text{O}_3$  crystal size and  $\text{SO}_2$  emissions requires evaluation.
6. An expected decrease in arsenic emissions by about 50%.

### Detailed Process Description

#### Vaporization of Arsenic Trioxide From Stockpile Dust

The crude  $\text{As}_2\text{O}_3$  from a surface storage bin is dried and fed to a reactor along with roaster off-gas. The fluosolids reactor/sublimator utilizes heat in the roaster off-gas to heat and sublime the arsenic in the crude dust. Gas cooling occurs (430° C to 370° C) with a net decrease in volume and increase in  $\text{As}_4\text{O}_6$  concentration. The heat balance is given in Appendix I.

The requirements of the reactor are twofold, namely (1) to obtain good gas/solid mixing and (2) to provide the necessary residence time for the vaporization of  $\text{As}_2\text{O}_3$ . Conceptually, the reactor size is determined by the vaporization kinetics which in turn is dependent on dust particle size and heat transfer. Data on this is lacking. The dust is known to be extremely fine (<2 microns) and is expected to vaporize readily at 370° C. The data needed for reactor sizing will have to be obtained from pilot plant tests. A coarse bed material would be required to maintain fluidity and provide a constant bed temperature. Inert solids from the roaster and from crude dust would be carried through the reactor.

The vapor pressure/temperature relationship of  $\text{As}_4\text{O}_6$  is given in table I. A temperature of 370° C can contain over 8000 g/m<sup>3</sup>  $\text{As}_4\text{O}_6$ . Condensation of  $\text{As}_4\text{O}_6$  from a gas stream containing 59.0 g/m<sup>3</sup> will begin at about 230° C.

### Hot Gas Filtration

Roaster off-gas, inerts and gaseous  $As_4O_6$  from the vaporization reactor pass into the high temperature sintered metal filter. Fine inert solids are retained on the filter and gaseous  $As_4O_6$  passes through. Filter size and design with blowback will be established from the RPC tests and current pilot plant testwork. Fine (0.2 to 1.0 micron) filters are required to remove inerts. With the flows shown in Figure I, a 98.0% solids filtration will yield a 98.0%  $As_2O_3$  product. The fine filter must be maintained above 250° C to prevent arsenic contamination of the inerts. These are transferred to the mill for gold recovery.

### Booster Blower

Pressure drop across the filter will be substantially higher than that currently found in the ESP. A booster blower will be required downstream of the filter to operate at 370° C. Enquiries are currently in progress regarding design and supply of a blower for this application.

### Arsenic Condenser

The hot gas from the blower is transferred to the existing fan mixer-condenser. Gas volumes are substantially reduced as given in the "General Process Description".

### Cold Baghouse

The condensed  $As_2O_3$  is removed from the carrier gas in the existing cold baghouse. With the gas flows reduced to less than one-half the current flow, baghouse utilization can be decreased proportionately with significant operating cost reduction.

Stack gas at 110° C will contain about twice the sulphur dioxide concentration. Arsenic concentration in the off-gas should be the same as in the present system. With reduced gas volume, overall arsenic emissions are expected to be about one-half the current rate.

### WAROX Packaging

The WAROX baghouse product will be compacted and flaked as outlined in the Fenco Engineers WAROX Feasibility Study (Dec. 1988).

Table 1.

VAPOUR PRESSURE - TEMPERATURE RELATIONSHIP FOR As<sub>4</sub>O<sub>6</sub>

Temp.(c)	Temp(k)	log p	As <sub>4</sub> O <sub>6</sub> p(mm Hg)	As <sub>4</sub> O <sub>6</sub> g/cu.m	As g/cu.m
90	363	-6.8005	0.00012	0.0021	0.002
100	373	-6.3514	0.00034	0.0058	0.0044
110	383	-5.9257	0.00090	0.0149	0.0113
120	393	-5.5218	0.0023	0.0369	0.028
130	403	-5.1378	0.0055	0.0871	0.066
148	421	-4.4927	0.0244	0.3683	0.279
170	443	-3.7754	0.127	1.825	1.382
180	453	-3.4724	0.256	3.586	2.716
200	473	-2.9049	0.946	12.69	9.610
220	493	-2.3834	3.144	40.46	30.64
240	513	-1.9025	9.513	117.6	89.09
260	533	-1.4577	26.490	315.3	238.8
289	562	-0.8787	100.49	1135.4	859.9
300	573	-0.6613	165.76	1835.2	1389.9
310	583	-0.4793	252.06	2742.8	2077.2
320	593	-0.3034	377.91	4042.9	3061.8
330	603	-0.1334	559.03	5881.4	4454.2
335	608	-0.0505	676.65	7060.3	5347.0
337	610	-0.0177	729.71	7589.0	5747.4
338	611	-0.0013	757.65	7866.6	5957.6

Range 90 -338 deg.C     $\log P(\text{atm})(\text{As}_4\text{O}_6) = - 6080.6/T(\text{deg K}) + 9.9506$

## Appendix I

### Preliminary Heat Balance for Sublimation of $As_2O_3$ From Underground Crude Storage Dust

The attached heat balance was carried out to determine the temperature drop in roaster off-gas that would result from addition of sufficient crude  $As_2O_3$  to meet a production target of 7000 t/y WAROX product. The balance is based on 3000 t/y  $As_2O_3$  from current roaster operations and 4000 t/y from stockpiled dust.

# Heat Balance Calculation

Crude Dust Treatment Rate Based On Gas Stream Temperature Drop  
from 430 deg C to 376 deg C

Gas Flow (ACFM) 8630 (SCFM) 3658  
Temp. In (deg K) 703  
Temp. Out (deg K) 649  
Gas Comp. % N2= 100 mole/min. 4236.40  
% O2=

Specific Heat cal/o/mole  
N2 6.66 +0.00102T  
Heat Content 1681316. cal/min.

Heat available from inerts (Fe2O3)

11.0 t/d  
7638.888 g/min  
47.83274 moles/min.

Specific Heat cal/o/mole  
Fe2O3 23.49+0.0186T-355000T-2

Heat Content of Fe2O3 91141.35 cal/min

Heat available from gaseous As2O3

11.0 t/d  
7638.888 g/min  
38.61925 moles/min.

Specific Heat of As2O3 vapour 21.5 cal/o/mole

Heat Content of As2O3 Fume 44836.95 cal/min.

Total heat available

N2 1681317  
Fe2O3 91141  
As2O3 (g) 44837

1817294. cal/min

Calculation of heat required to raise crude As2O3 to 371 deg C  
and sublime As2O3

(calculation for 1.0 kg dust)

Composition %As2O3 50  
%Fe2O3 50  
Moles As2O3 2.53  
Moles Fe2O3 3.14

Heat required to raise solids temp. from 298 deg K to 644 deg K

Specific Heat cal/o/mole  
As2O3(g) 21.5  
As2O3(s) 8.37 +0.04860T

Heat Content of Solid As2O3 Product 27815.95 cal/kg dust

Heat Content of Fe<sub>2</sub>O<sub>3</sub> 33622.64 cal/kg dust

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Heat required to sublime As<sub>2</sub>O<sub>3</sub>

Heat of Sublimation of As<sub>2</sub>O<sub>3</sub> 15.25 kcal/mole As<sub>2</sub>O<sub>3</sub>

Heat Required for Sublimation 38510.10 cal/kg feed

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Total heat required per kg crude dust

As<sub>2</sub>O<sub>3</sub> 27815.95

Fe<sub>2</sub>O<sub>3</sub> 33622.64

As<sub>2</sub>O<sub>3</sub> sub 38510.10

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99948.70 cal/kg dust

Total heat available 1817294. cal/min

Heat Loss (10 %) 272594

Net Heat Available 1544700.

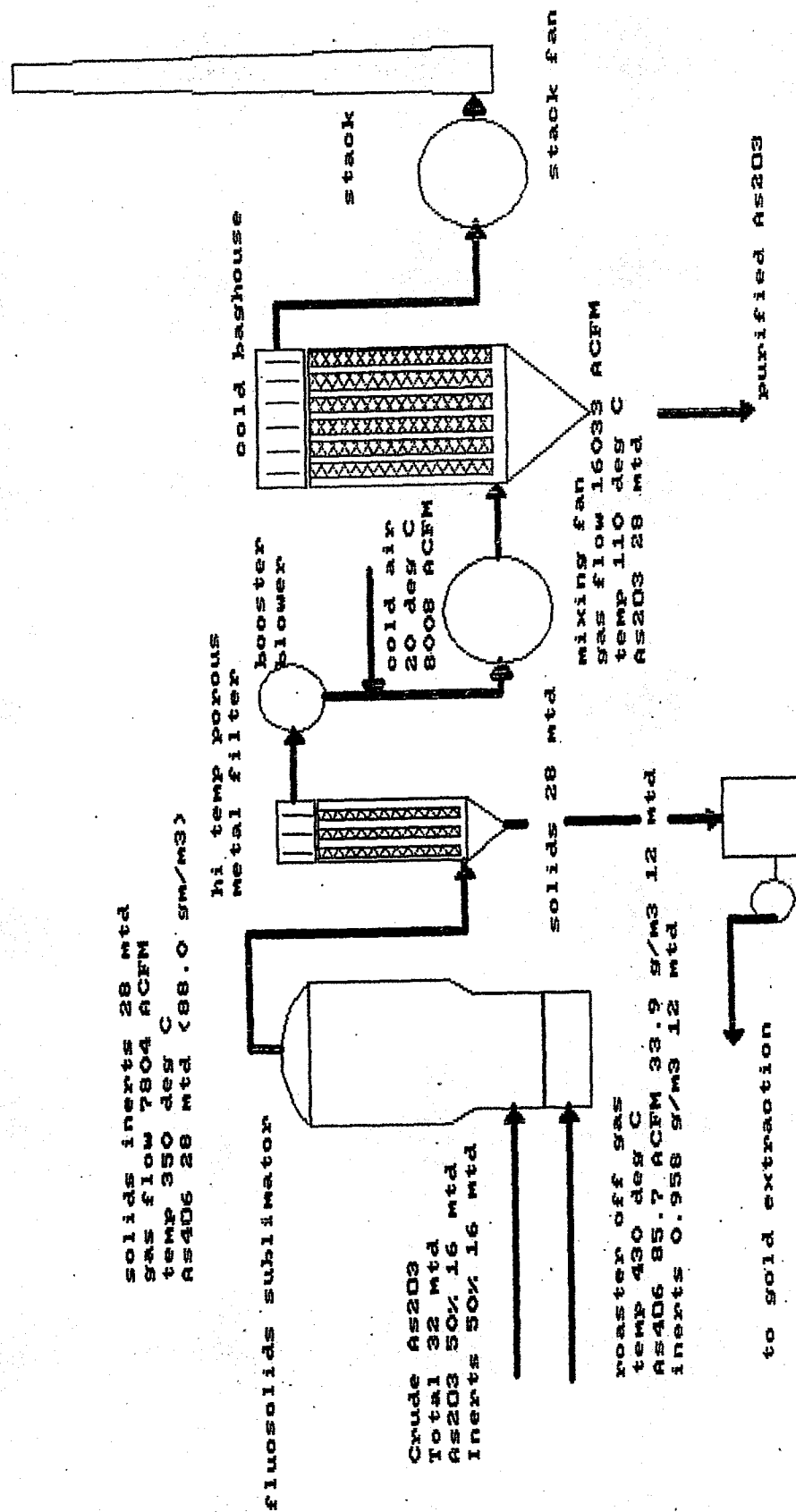
Dust feed 15.45493 kg/min

22.25510 t/day

Calculations for flow sheet treating 22.0 t/d  
dust continuously - 365 d/y, 24 h/d.

# WAROX Process Flowsheet

Basis - 7000 mty AS203  
 250 operating days  
 5 days/wk @ 24 hr/d  
 Prepared by M.R. Hatch  
 June 19, 1990



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MEMORANDUM

TO: S. McAlpine  
CC: K. Blower, G. Halverson, R. Braconnier  
FROM: K. Morton  
DATE: April 10, 1990  
SUBJECT: REPLACEMENT OF COTTRELLS WITH HI TEMP FILTER

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I have asked all three sintered metal filter manufacturers (Fluid Dynamics, Mott and Pail) to provide us with a budget estimate for a filter installation that would replace the Cottrells. Design operating conditions were described as follows:

OPERATING CONDITIONS:

gas temperature	450 deg C.
gas volume	8227 ACFM
particulate loading	23 stpd
operating pressure	slightly negative
operating period	24 hrs/day 7 days/week
maintenance shutdowns	none
gas composition	7% SO <sub>2</sub> , 7% As <sub>2</sub> O <sub>3</sub>
materials of construction	carbon steel, mild steel
particle size	2% <.5 micron, 70% < 3 micron

So far only Pall has responded with a budget quote, but I was encouraged to find that this company, which is likely to be the most expensive, has quoted a price that is within my earlier estimate of \$740,000 (\$440,000 to purchase, \$300,000 to install).

Pall suggested two alternatives for the installation:

Option I: A single vessel, multiple plenum system that is on line 100% of the time, plenums being isolated in sequence for blowback. This is a downdraft venturi blowback system. Price \$324,043.

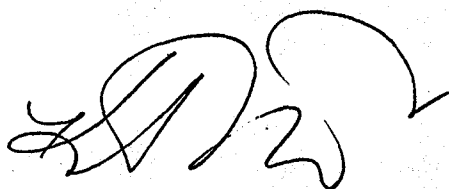
OPTION II: Dual vessels having 50% more capacity overall, otherwise same features as option I. Price \$510,612.

Both options come complete with all controls, tubesheets, filter elements, etc. and both are sized for 8 ACFM/sq.ft of filter area, a relatively conservative design.

Even if we choose not to reclaim arsenic from underground, replacement of the Cottrells with these filters would still make a lot of sense. The potential benefits have been mentioned before but are probably worth mentioning again.

1. Improved recovery of gold in flue dust. This would have amounted to 94 ounces in February.
2. Improved carbon plant recovery due to lower soluble arsenic concentrations in the carbon plant feed. I feel that as much as 40 oz/mo may be available from this source.
3. Reduced wastewater treatment costs due to lower soluble arsenic concentrations in carbon plant feed.
4. Arsenic trioxide grading better than 99%. All of the product produced at this grade can be sold at a profit.
5. Reduced arsenic storage costs because of the above.
6. Reduced building heating and maintenance costs because of the small space taken up by the new filters.
7. Reduced equipment operating and maintenance costs. Hi temp filters are low maintenance installations. Power consumption depends on pressure drop across the filters that is required to achieve capture of particulates.

If all of these benefits are considered, payback is much less than one year, even if arsenic is never recovered from underground.



Kent Morton

Mott Budget Quote for Blowback System

3 vessels online, \$200,000 US. per vessel, total \$600,000 US.  
Each vessel 72" dia containing 313 40" 2 to 5 micron elements  
face velocity 4 ACFM/sq/ft. (sintered powdered metal media)  
venturi pulse blowback system, 1 scf pulse air per element

Fluid Dynamics Budget Quote for Blowback System

3 vessels online, 1 vessel on standby \$150,000 - \$175,000 US total  
192 5.8 sq.ft. elements, 835 sq.ft online.  
face velocity 10 ACFM. (sintered fabric metal media)  
differential pressure 5 - 10" wg.  
price includes all controls, valves, elements, housings, etc..