

FALCONBRIDGE NICKEL MINES LIMITED

INTER-OFFICE MEMORANDUM

DATE: October 23, 1980

TO: D. J. Emery

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K.S.Morton; W.A.Moore

FROM: S. O. Fekete

SUBJECT: Capital and Operating Cost for As₂O₃ Recovery at Giant Yellowknife

1) Introduction

In accordance with our discussions, the economic potential of purifying arsenic bearing materials available to the Giant operation were examined. It was assumed that the fuming technique would be developed and adopted for the commercial operation. Three cases, involving different feed sources and/or production rates were examined:

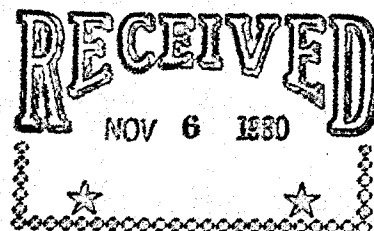
- Case 1. Uses current production of baghouse dust plus an equal amount of Con pond sludge material to produce 12×10^6 lbs/year purified As₂O₃. The residue produced would be processed through the carbon plant to recover the contained gold, thus add to the revenue base.
- Case 2. Only current production of baghouse dust would be processed to produce 6.9×10^6 lbs/year purified As₂O₃.
- Case 3. Current production of baghouse dust would be augmented by reclaiming dust from the underground storage vaults, to produce 12×10^6 lbs/year purified As₂O₃.

The cost of constructing and operating a fuming pilot plant to develop the technique and furnish design data for a commercial plant was also estimated.

2) Summary

On the basis of tests conducted at FML it was concluded that fuming has to be carried out rapidly, at temperatures and As₄O₆ vapour contents in the gas phase that promote sublimation rather than fusion and vaporization of the molten As₂O₃. If fusion is allowed to occur, the charge consolidates into sticky masses, that would cause operational difficulties while also inhibiting heat transfer and volatilization of the arsenic trioxide. In the presence of significant gold values, exposure of the residue to excessive temperatures would cause loss of gold recovery.

Carrying out the fuming in a fluidized system, consisting of a bed of wet material (SiO₂ sand, iron oxide, or possibly flotation tailings from the mill), fluidized by hot combustion gases, that also serves as a heat carrying medium, would appear to meet the requirements of the process.



The significant production and financial data as estimated for the three cases considered are summarized in Table 1. The figures indicate that:

- a) All three cases are potentially profitable.
- b) Case 1, involving treatment of current baghouse dust with Con pond sludge, will likely be the least profitable on the basis of rate of return on investment, but would be the highest on cash flow. This is due to high cost of the drying installation which the other cases do not require, partially offset by the additional revenues from gold. The profit potential of Case 1, would further diminish by additional charges, not allowed for in either operating or capital cost for reclaiming the Con pond sludge, and sharing of revenues with Cominco.
- c) The best rate of return will likely result from the implementation of Case 3. However, the technical feasibility of reclaiming material from the underground storage vaults and the cost of reclamation must be carefully reviewed before this conclusion can be firmed up.

Providing that Giant's management considers that the economic merits relative to the risk involved justify undertaking this program it is recommended that:

- a) The pilot plant program, to develop the fuming, gas cleaning and condensing operations, be reviewed to ascertain that the funds, personnel and time estimated, are realistic in relation to other commitments and availability of resources. It is important to recognize the need for the full time involvement of at least one professional during design, construction and operation of the pilot plant.
- b) Upon conclusion of the development program the technical feasibility and economics of the venture be reassessed on the basis of firmed up design data and vendor quotation for equipment.
- c) Discussions with Cominco on the potential to reclaim and treat their pond material, be approached with the understanding that the economics will not necessarily be in Giant's favour, relative to other options, if a substantial portion of the revenues have to be shared.

Table 1 (Cont'd.)

Table 1. Summary of Significant Production and Financial Data for Arsenic Oxide Production at Giant Yellowknife

		X		
1)	<u>Plant feed constituents & quantities</u>	<u>Case 1</u>	<u>Case 2</u>	<u>Case 3</u>
	Current Baghouse dust kg/Hr	450 ✓	450 ✓	450 ✓
	Reclaimed underground material "	- ✓	-	333 ✓
	Con Pond sludge - dry "	450 ✓	-	-
	Total dry feed "	900	450	883
	Feed composition: Wt % (dry basis) As ₂ O ₃	78.4	90.0	90.0
	oz/ton gold	0.2	- OK	-
2)	<u>Production</u>			
	Purified As ₂ O ₃ produced: 10 ⁶ lbs/year	12.0	6.9	12.0
	Gold Produced oz/year	1100.	-	-
3)	<u>Revenues:</u> in \$Can 000's			
	As ₂ O ₃ sales (@ \$Can <u>0.30</u> /lb Netback) <i>High</i>	3600	2070	3600
	Gold sales (@ \$Can <u>750</u> /oz) <i>High</i>	825	-	-
	Total revenues	4425	2070	3600
4)	Estimated Operating Cost - in \$Can 000's	691	405	643
5)	Revenues after Treatment charges in \$Can 000's	3734	1665	2957
6)	Capital cost in \$Can 000's	1876	789	1050

3) Description of Alternatives

a) Sources and quantities of plant feed

For the purpose of determining the impact of treating various feed materials available on the economics, three alternatives were considered:

Case 1

Con pond sludge material would be received and dried in a rotary dryer and the dry product mixed with current production of baghouse dust. On the basis of the analysis available to us the amount of dry Con pond sludge would be equal to that of the baghouse dust (450 kg/Hr) and the mixture of the two, amounting to 900 kg/Hr, would be treated in the fuming installation to produce 12×10^6 lbs/year purified As_2O_3 . The residue collected in a hot baghouse would be forwarded to the carbon plant for gold recovery. For estimating purposes, it was assumed that 70% of the gold contained in the Con pond sludge would be recovered in bullion form. The dryer installation was sized and costed out on the basis of one shift per day operation with sufficient surge for mixing with the baghouse dust and treatment of the mix on a 24 hour day basis.

Case 2

Only current production of baghouse dust would be treated in the fuming installation to produce 6.9×10^6 lbs/year of purified As_2O_3 . The residue would be discarded, assuming that the gold value contained is insufficient to justify treatment in the carbon plant.

Case 3

Current production of baghouse dust would be augmented by reclaiming dust from the underground storage vaults, to produce 12×10^6 lbs/year purified As_2O_3 . It was assumed that the product reclaimed from underground storage would be dry and of the same composition as that of the current production baghouse dust and that the gold values in the residue are insufficient to justify treatment in the carbon plant.

Annual quantities for the various cases are tabulated in Table 2.

Table 2. Assumed Sources and Quantities of Feed and Products for the Various Cases

<u>Fuming system feed:</u>		<u>Case 1</u>	<u>Case 2</u>	<u>Case 3</u>
Current Production Baghouse Dust	MT/year	3564	3564	3564
Reclaimed underground material	MT/year	-	-	2637
Con Pond sludge - dry	MT/year	3564	-	-
Total dry feed		7128	3564	6201
As_2O_3 content of dry feed	wt%	78.4	90.0	90.0
Gold Content of dry feed	oz/ton	0.2	-	-
<u>Productions</u>				
Purified As_2O_3 produced 10^6 lbs/year		12.0	6.9	12.0
Gold recovered @ 70% Recovery	oz/year	1100	-	-

b) Process description

b-1) Drying Circuit

The drying circuit flowsheet is shown in Appendix A, Figure 1A. This system only applies to Case 1. for drying the Con pond sludge. The battery limits start with the surge hopper for receiving and storing the equivalent of one days production of Con pond sludge and terminate with an exhaust fan to deliver the flue gas to the existing roaster flue gas system (probably will serve as a replacement of some of the quench air currently used ahead of the baghouse) and a surge hopper storing the dry material before delivery to the fuming installation. The installation was sized and costed on the basis of operating one shift per day to produce the necessary amount of dry material to be mixed with current production of baghouse dust for treatment in the fuming system.

The material from the surge hopper would be removed at the required rate (about 2 MT/Hr) and delivered via screw feeder into a propane fired Link-Belt Roto-Louvre dryer. The end section of the dryer would be fitted with a trommel screen, scalping out the lumps which would be broken up by a lump breaker (roll crusher or similar device) before it rejoins the stream of fines on a conveyor leading to the dry surge hopper. The dry product would be removed and delivered as needed in the fuming area by an endloader. The combustion gases leaving the dryer would be exhausted and delivered to the existing roaster flue system.

b-2) Fuming Circuit

The fuming circuit flowsheet is shown in Appendix B, Figure 1B, and applies to all three cases. For Case 1 and Case 3, the treatment rates are nearly the same, hence equipment sizes, for all practical purposes would be the same. For Case 2, the treatment rate would be lower hence equipment sizes would be smaller.

The dry feed would be introduced into a bucket elevator booth via an end loader and elevated to the feed hopper. The feed hopper is sized to hold one days' supply. The dry feed would be metered into the fluid bed via a pneumatic feeder.

The fluid bed fuming furnace would consist of a firing chamber (dutch oven) producing combustion gases at 1650°F by burning propane under pressure to be introduced via the tuyeres into the fluid bed consisting of sand or other suitable material. The hot combustion gases would serve as a fluidizing medium and a heat carrier to supply the necessary energy for the fuming. The temperature in the fluid bed would be maintained in the range of 350 to 400°C by modulating the dry feed input.

The flue gases leaving the fluidizer would pass through a cyclone to capture any coarse dust particles and then to a baghouse equipped with heat resistant bags (marketed by Aerex Corporation) to capture the fine residue. The purified gas containing the arsenic oxide vapours would be cooled by direct contact with ambient air of sufficient quantity to cool the gases to 150°C and condense the arsenic oxide. Subject to verification through pilot plant studies, the

condenser would consist of a cylindrical chamber, receiving the hot gases axially on one end and being fed with cooling air tangentially at several points along the length of the condenser. The gradual cooling is expected to promote crystal growth and produce a relatively coarse product for ease of handling. The cooled gases, carrying the solid arsenic oxide, would pass through a second baghouse to collect the arsenic oxide, while the clean gases would be exhausted to either the existing baghouse or the existing stack directly. The purified arsenic oxide would be removed to the product silo for delivery to market.

The fine dust collected in the hot baghouse would be removed and discarded or passed on to the carbon plant for gold recovery. Since the quantity of this dust is expected to be small it was assumed that it would be dumped from the hot baghouse intermittently and allowed to air cool before further handling.

For the purposes of estimating, it was assumed that a bucket elevator would be used for elevating the dry feed to the feed hopper level. This may not be an acceptable approach because of excessive dusting and problems with maintaining ambient air standards. An alternative would be to use the pneumatic system currently employed for delivering the dust to the underground storage vaults. It was assumed that this system could be revamped to allow delivery of the dust to underground or to the feed hopper and the cost of the revamp would be equal to the cost of the bucket elevator installation.

4. Operating Cost Estimates

a) Labour Requirements

It was assumed that the fuming circuit would be operated on a 24 hour seven day per week basis and would require 8 operators on the payroll. Supervision was assumed to cost 15% of the direct operating labour cost.

The drying circuit for Case 1, was assumed to be operated on dayshift only and that it would take 3 men on the payroll to operate on a seven day basis with at least two being in attendance at all times.

The propane consumption was estimated on the basis of mass and energy balances shown in the Appendix. Power will only be required for the various drives and will be a minor cost component, therefore only nominal allowances were made.

Cost of repair and maintenance was estimated on the basis that the hot baghouse will require four complete bag replacements per year while the cold baghouse will require two complete bag replacements per year. Other maintenance costs were assumed to be about 10% of the estimated purchased equipment cost (maintenance materials plus labour).

The cost of reclaiming underground storage material was assumed to be \$55/M ton reclaimed. This figure was taken on the basis that underground hardrock mining on a fairly large scale costs about \$25/M ton ore hoisted to surface. Since this represents a fairly large cost element for Case 3, it may deserve a closer scrutiny by the operating staff and adjustment.

The estimated operating costs are tabulated in Table 3. Potential additional costs not included in the estimate are as follows:

- a) cost of reclaiming and transporting the Con pond sludge to the drying circuit.
- b) cost of treating the fuming furnace residue in the carbon plant for gold recovery.

Giant's costs, associated with the foregoing two items depend on the cost and revenue sharing arrangement with Cominco and should be taken into consideration if and when discussions with them take place.

Table 3 Estimated annual operating cost for the arsenic oxide purification at Giant Yellowknife

	Case 1	Case 2	Case 3
Operating labour - no. of men on payroll	11	8	8
Propane consumed - m. Tons per year:			
Drying con pond sludge	137	-	-
Fuming furnace	<u>130</u>	<u>70</u>	<u>119</u>
Total propane MT/year	267	70	119
Electric power for drivers - allowance: HP	60	30	50
<u>Annual costs in 000's of \$Can</u>			
Operating labour @ \$30,000/man	330.0	240.0	240.0
Supervision @ 15% of operating labour	50.0	36.0	36.0
Repairs: bag replacement	55.0	27.0	55.0
Other repair costs	40.0	13.0	20.0
Energy cost: propane @ \$420/MT	112.0	29.0	50.0
power @ \$310/HP year	19.0	9.0	16.0
Reclaiming of underground storage material @ \$55/metric ton (1)	-	-	145.0
Contingency allowance @ 15%	<u>85.0</u>	<u>51.0</u>	<u>81.0</u>
Total annual operating costs ⁽²⁾	691.0	405.0	643.0

5) Capital Cost Estimate

On the basis of equipment sizes derived from mass and energy balances, vendors were requested to quote budget prices on equipment, FOB manufacturers plant. The installed cost was developed by the use of factors for direct and indirect cost. In keeping with the quality of this type of estimating an allowance of 25% for contingencies and fees was made to arrive at the fixed capital cost. The cost for Case 2, is based on Case 3 cost, reduced by the ratio of throughputs to the 0.75 power. The development cost, based on details shown in Appendix C, were also included in the capital cost.

Items not included in the costs, for which allowances must be made once better definitions on the project scope are on hand, are as follows:

- a) In case 1, equipment, if any, for reclaiming and delivery con pond sludge to the drying circuit.
- b) In case 3, equipment, if any, required in the reclaiming of underground storage material.
- c) Preproduction expenses, such as preparing the con pond and the underground storage vaults for reclaiming materials.
- d) Working capital

Table 4 Capital cost Estimate (Cont'd.)....

Table 4 Capital cost Estimate for Arsenic Oxide Purification
at Giant Yellowknife

		\$ Can. in 000's					
		Case 1		Case 2		Case 3	
1) Direct Field costs:							
Equipment		410		132	-	200	
Field installation:							
materials (50% of equip)		205		66		100	
labour (50% of equip.)		<u>205</u>		<u>66</u>		<u>100</u>	
subtotal direct field cost		820	820	264	264	400	400
2) Indirect costs:							
Construction overhead (25% of dir. field cost)		205		66		100	
Engineering & procurement (10% of dir. field cost)		82		27		40	
Equipment freight (15% of equipment)		<u>61</u>		<u>20</u>		<u>30</u>	
		348	348	113	113	170	170
3) Buildings 30% of equipment		-	123	-	40	-	60
4) Contingencies and fees @ 25%		-	<u>323</u>	-	<u>110</u>	-	<u>158</u>
Total fixed capital		-	1614	-	527	-	788
5) Development cost		-	<u>262</u>	-	<u>262</u>	-	<u>262</u>
Total Cost			<u>1876</u>		<u>789</u>		<u>1050</u>

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Appendices A, B, & C

APPENDIX A

Con-Arsenic Sludge Drying Circuit

- 1) Flowsheet
- 2) Mass and Energy Balance
- 3) Equipment List

APPENDIX - A

FIGURE A1 - CON ARSENIC SLUDGE DRYING CIRCUIT

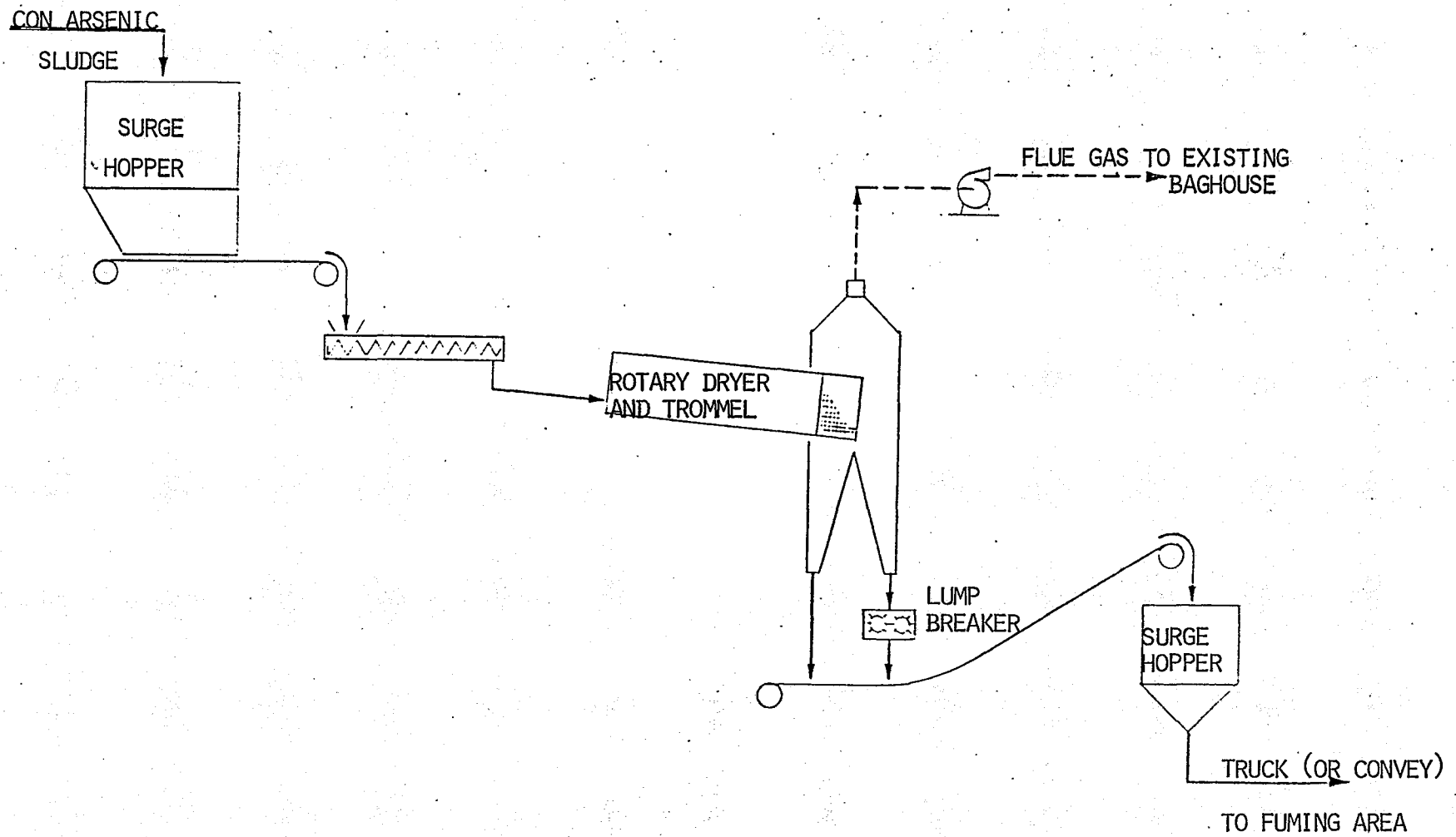


Table A1 Con-Arsenic Drying Circuit Mass and Energy Balance

Note: 15,428 kg/day wet feed @ 30% moisture

10,800 kg/day dry

Operation to be sized for one shift operation, 6 operating hours, per day.

1) <u>Mass & Heat Balance</u>	<u>Mass Rate</u>		<u>Heat effects</u> K cals.		Total K cals in 000's
	<u>Kg/Hr</u>	<u>Kg moles per Hour</u>	<u>Per Kg</u>	<u>Per Keg mole</u>	
<u>Input:</u>					
Con Arsenic sludge @ 25°C: solids	1800.0				
water	771.4	42.85			
Combustion air @ 25°C	-	108.76			
propane	60.0	1.36	11,100	-	<u>666.0</u>
Total input					<u>666.0</u>

Output

Dry Con-Arsenic product @ 100°C	1800.0	-	18.75	-	33.8
Sludge water: vapourization	771.4	42.85	583.9	-	450.4
sensible heat @ 127°C	-		45.8	-	35.3
combustion gases @ 127°C =					
Co ₂	-	4.08	-	954.8	3.9
H ₂ O	-	5.44	-	824.9	4.5
O ₂	-	16.04	-	725.1	11.6
N ₂	-	85.92	-	710.1	61.0
Heat losses	-	-	-	-	<u>66.5</u>
Total output		<u>154.33</u>	-	-	<u>666.0</u>

2) Flue Gas Composition & Volume

	<u>Volume</u>		<u>Volume</u> %
	<u>Nm³/Hr</u>	<u>Cfm @ 127°C</u>	
Co ₂	91.4	78.8	2.6
H ₂ O	1081.7	932.8	31.3
O ₂	359.3	309.8	10.4
N ₂	<u>1924.6</u>	<u>1659.7</u>	<u>55.7</u>
Total	<u>3457.0</u>	<u>2981.1</u>	<u>100.0</u>

Appendix ATable A-2Con Arsenic Drying Circuit Equipment List

1)	Surge hoppers (two required) for dryer feed and product. 3 m long x 2 m wide, 2 m high straight section, and 1.5 m high, sloping bottom. Estimated volume: 16 m ³ estimated weight: 2250 kg.	10,000
2)	Belt feeder. 60 cm wide 3.7 meters long	15,000
3)	Rotary dryer package to include dryer, exhaust fan, combustion chamber, combustion air blower, combustion hardware and screw feeder.	165,000
4)	Lump breaker - costed as 10" x 6" Denver equipment type roll crusher.	15,000
5)	Belt conveyor to deliver dryer product from dryer discharge to surge hopper. 0.5 m wide, 15 meters long. @ \$350/meter.	<u>5,000</u>
Total Equipment Cost		210,000

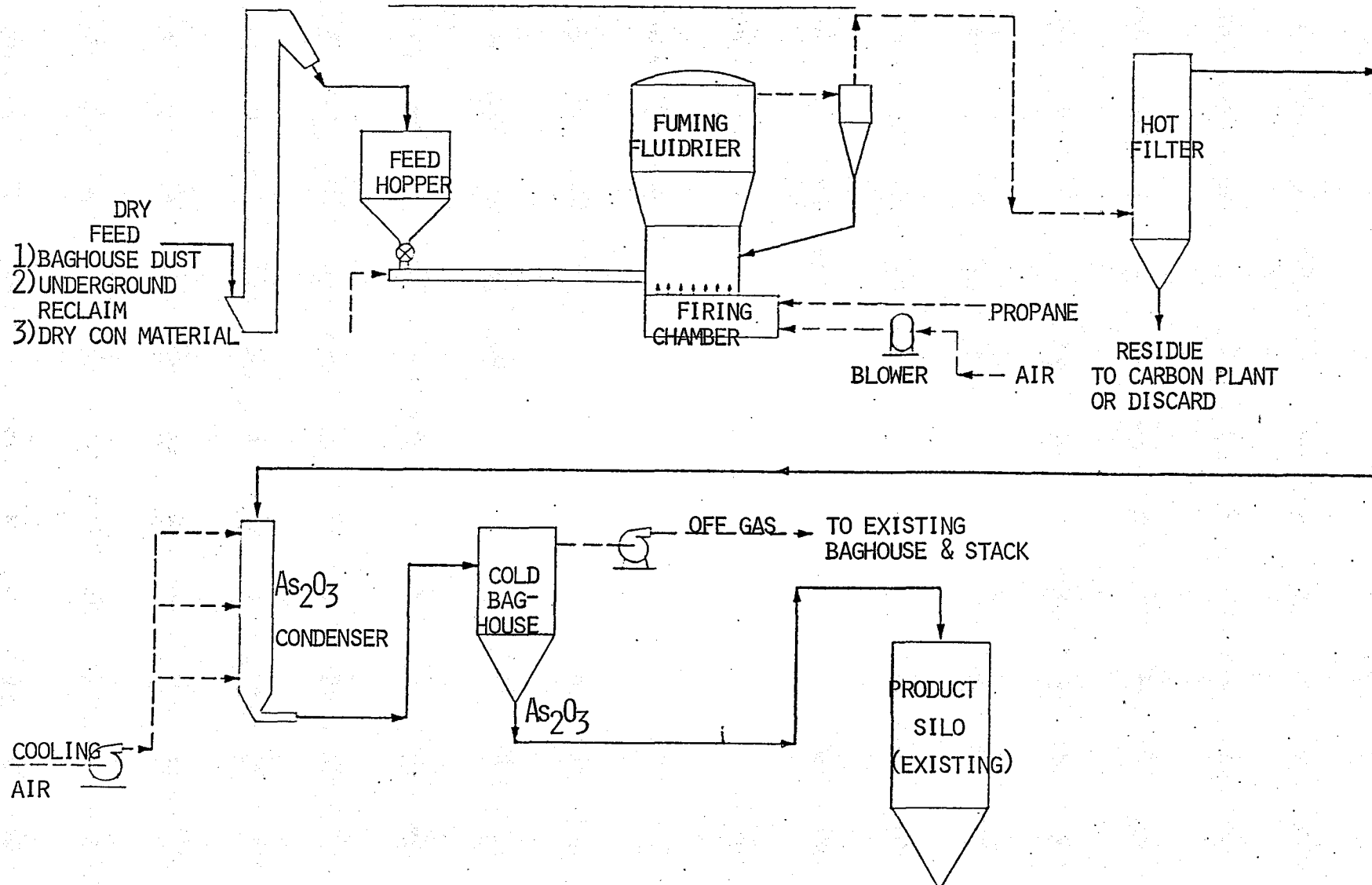
APPENDIX B

Fuming Circuit

- 1) Flowsheet
- 2) Mass and Energy balances for 3 cases
- 3) Gas composition and volumes for 3 cases
- 4) Equipment list & cost

APPENDIX - B

FIGURE B1 - FUMING CIRCUIT FLOWSHEET



Case I

		Mass Rate		Heat effects K cal's.		Total K cal's in 000's
		Kg/Hr	Kg moles per Hour	Per Kg	Per Kg mole	
<u>Input</u>						
Dry Con pond material	@ 25°C	450.00	-	-	-	-
Baghouse dust	@ 25°C	450.00	-	-	-	-
Combustion air	@ 25°C	-	22.46	-	-	-
Propane		14.2	0.32	11,100	-	157.6
Total input						157.6
<u>Output</u>						
Residue	@ 400°C	194.8	-	75.0	-	14.6
As ₄ O ₆ vapours:						
:heat of volatolization		705.2	1.78	77.1	-	54.4
:sensible heat @ 400°C		-	-	22.5	-	15.9
Combustion products @ 400°C	CO ₂	-	0.97	-	3939	3.8
	H ₂ O	-	1.29	-	3152	4.1
	O ₂	-	3.10	-	2779	8.6
	N ₂	-	17.74	-	2658	47.2
Heat losses		-	-	-	-	9.0
Total output						157.6

Table B 2 - Condenser Mass and Energy Balance

CASE I

	<u>Mass Rate</u>		<u>Heat effects K cal.</u>		<u>Total K cal in 000's</u>
	<u>Kg/Hr</u>	<u>Kg moles per Hour</u>	<u>Per Kg</u>	<u>Per Keg mole</u>	
<u>Input:</u>					
Sensible heat of fuming Fce off gases at 375°C : CO ₂	-	0.97	-	3354	3.3
H ₂ O	-	1.29	-	2712	3.5
O ₂	-	3.10	-	2389	7.4
N ₂	-	17.74	-	2293	40.7
As ₄ O ₆	705.2	1.78	21.0	-	14.8
heat of condensation of As ₄ O ₆ vapours	-	-	77.1		54.4
cooling air at 25° C	-	<u>101.50</u>	-	-	<u>0</u>
Total input		126.38			124.1
<u>Output:</u>					
Sensible heat of gases leaving condenser at 150°C : CO ₂	-	0.97	-	1192	1.2
H ₂ O	-	1.29	-	1016	1.3
O ₂	-	24.42	-	893	21.8
N ₂	-	97.92	-	872	85.4
sensible heat of As ₂ O ₃ at 150°C	705.2	-	16.25	-	11.5
heat losses	-	-	-	-	<u>2.9</u>
Total output	-	124.60	-	-	124.1

Table B 3 - Fuming Furnace Mass & Energy Balance

CASE 2

	Mass Rate		Heat effects K cal.		Total K cal in 000's
	<u>Kg/Hr</u>	<u>Kg moles per Hour</u>	<u>Per Kg</u>	<u>Per Keg mole</u>	
<u>Input</u>					
Baghouse dust at 25°C	450.0	-	-	-	-
Combustion air	-	12.00	-	-	-
Propane	7.6	<u>0.17</u>	11,100	-	<u>84.4</u>
Total input	-	12.17	-	-	84.4
<u>Output</u>					
Residue at 400°C	45	-	75.0	-	3.4
As ₄ O ₆ vapours : heat of volatalization	405	1.02	77.1	-	31.2
: sensible heat at 400°C	-	-	22.5	-	9.1
Combustion products at 400°C					
CO ₂	-	0.52	-	3939	2.0
H ₂ O	-	0.69	-	3152	2.2
O ₂	-	1.66	-	2779	4.6
N ₂	-	9.48	-	2658	25.2
Heat Losses	-	<u>-</u>	-	-	<u>6.7</u>
Total output		13.37			84.4

Table B4 - Condenser Mass and Energy Balances

Case 2

		<u>Mass Rate</u>		<u>Heat effects K cal.</u>		<u>Total K cal in 000's</u>
		<u>Kg/Hr</u>	<u>Kg moles per Hour</u>	<u>Per Kg</u>	<u>Per Keg mole</u>	
<u>Input</u>						
Sensible heat of fuming furnace						
off gases @ 375°C:	CO ₂	-	0.52	-	3354	1.7
	H ₂ O	-	0.69	-	2712	1.9
	O ₂	-	1.66	-	2389	4.0
	N ₂	-	9.48	-	2293	21.7
	As ₄ O ₂	405	1.02	21.0	-	8.5
Heat of condensation of As ₄ O ₆ vapours		-	-	77.1	-	31.2
Cooling air @ 25°C		-	55.2	-	-	-
Total input			68.57			69.0
 <u>Output</u>						
Sensible heat of gases leaving						
condenser at 150°C:	CO ₂	-	0.52	-	1192	0.6
	H ₂ O	-	0.69	-	1016	0.7
	O ₂	-	13.25	-	893	11.8
	N ₂	-	53.10	-	872	46.3
Sensible heat of As ₂ O ₃ @ 150°C		405	-	16.25	-	6.6
Heat losses		-	-	-	-	3.0
			67.56			69.0

Table B5 - Fuming Furnace Mass & Energy BalanceCase 3

	<u>Mass Rate</u>		<u>Heat effects K cal.</u>		<u>Total K cal in 000's</u>
	<u>Kg/Hr</u>	<u>Kg moles per Hour</u>	<u>Per Kg</u>	<u>Per Keg mole</u>	
<u>Input</u>					
Baghouse dust @ 25°C	450.0	-	-	-	-
Reclaimed underground material	333.0				
Combustion air @ 25°C	-	21.00	-	-	-
Propane	13.0	<u>0.30</u>	11,100	-	<u>144.3</u>
Total input	-	21.3	-	-	144.3
<u>Output</u>					
Residue at 400°C	78.3	-	75.0	-	5.9
As ₄ O ₆ vapours:					
: heat of volatilization	704.7	1.78	77.1	-	54.3
: sensible heat @ 400°C	-	-	22.5	-	15.9
Combustion products @ 400°C					
CO ₂	-	0.90	-	3939	3.5
H ₂ O	-	1.20	-	3152	3.8
O ₂	-	2.90	-	2779	8.1
N ₂	-	16.60	-	2658	44.1
Heat losses	-	<u>-</u>	-	-	<u>8.7</u>
Total output		23.38			144.3

Table B 6 - Condenser Mass & Energy Balance

CASE 3

	Mass Rate		Heat effects K cal.		Total K cal in 000's
	Kg/Hr	Kg moles per Hour	Per Kg	Per Keg mole	
<u>Input</u>					
Sensible heat in fuming furnace					
off gases at 375°C: CO ₂	-	0.90	-	3354	3.0
H ₂ O	-	1.20	-	2712	3.3
O ₂	-	2.90	-	2389	6.9
N ₂	-	16.60	-	2293	38.1
As ₄ O ₆	704.7	1.78	21.0	-	14.8
heat of condensation of As ₄ O ₆ vapours	-	-	77.1	-	54.3
cooling air at 25°C	-	96.00	-	-	-
Total input					120.4
<u>Output</u>					
Sensible heat of gases leaving condenser					
at 150°C: CO ₂	-	0.90	-	1192	1.1
H ₂ O	-	1.20	-	1016	1.2
O ₂	-	23.06	-	893	20.6
N ₂	-	92.44	-	872	80.6
sensible heat of As ₂ O ₃ at 150°C	704.7	-	16.25	-	11.5
heat losses	-	-	-	-	5.4
Total output					120.4

Appendix B

Table B 7 - Fuming Circuit Gas Composition and Volumes

1) Fuming Furnace Off Gases:			Case 1	Case 2	Case 3
Composition:	Vol %	CO ₂	3.9	3.9	3.9
		H ₂ O	5.2	5.2	5.1
		O ₂	12.5	12.4	12.4
		N ₂	71.3	70.9	71.0
		As ₄ O ₆	7.1	7.6	7.6
		Total	100.0	100.0	100.0
Volume	kg moles/Hr		24.9	13.4	23.4
	m ³ /Hr @ 400°C		1374	738	1291
	cfm @ 400°C		809	435	760
2) Condenser Outlet					
Composition:	Vol %	CO ₂	0.8	0.8	0.8
		H ₂ O	1.0	1.0	1.0
		O ₂	19.6	19.6	19.6
		N ₂	78.6	78.6	78.6
		Total	100.0	100.0	100.0
Volume	kg moles/Hr		124.6	67.6	117.6
	m ³ /Hr @ 150°C		4325	2345	4082
	cfm @ 150°C		2545	1380	2402
3) Condenser Cooling air:					
	kg moles/Hr		101.5	55.2	96.0
	m ³ /Hr @ 15°C		2399.0	1304	2269
	scfm		1412.0	768	1335

Table B8 - Fuming Circuit Equipment List

(Sizes and costs apply to Case 1 & Case 3 only)

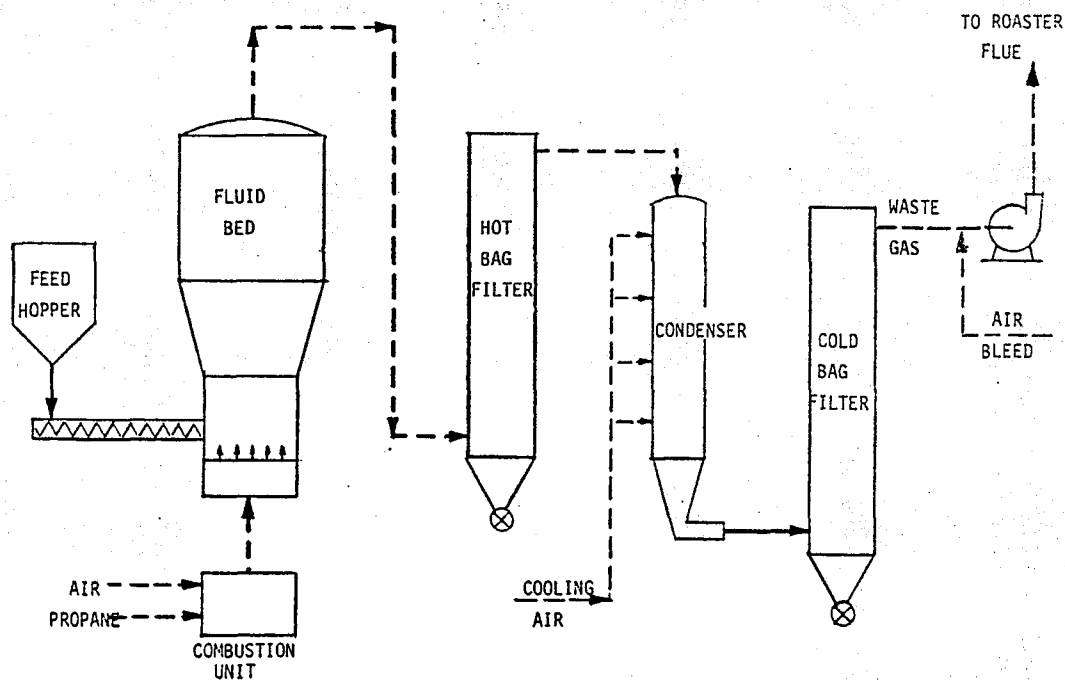
Item No.	<u>Description</u>	Cost \$ Can
1)	Bucket Elevator 6" x 4" buckets (smallest available from FMC) 25 feet lift	15,000
2)	Feed hopper: 15 m ³ working volume 2.75 m diamter, 2 m high at straight section, 1.5 m high cone bottom: approx. wt. 2000 kg	4,500
3)	Fluidizer package unit to include: pneumatic feeder for metering the feed, cyclone, "dutch oven" type combustion chamber with burner, air compressor and controls. Fluidizer proper to be of 1.0 meter diameter in the hearth area, refractory lined to 1.2 meter height, 1.2 meter diameter freeboard, 3.5 meter high, the whole unit with external insulation.	130,000
4)	Hot Baghouse, Aerex Corporation type equipped with 24 Pyrotex B bags for continuous operation at 400°C, compartment with outside insulation, top entry for bag replacement and necessary controls and hardware for dust dislodging.	31,000
5)	Condenser - Cylindrical carbon steel vessel schedule 20, 18" pipe, 15 feet long, equipped with an axial inlet for arsenic bearing gases, multiple tangential inlet for cooling air and axial outlet for cooled gas. Approx. wt 900 lbs.	1,500
6)	Cold baghouse - Aerex type equipped with 64 pyrotex GT bags for continuous service at 150°C, carbon steel baghouse compartment with top entry for bag replacement and controls	13,000
7)	Condenser cooling air blower, Sheldon exhausted, Size 9 type X0, for 1600 scfm at 8" W.G., ambient temperature	1,650
8)	Tail gas exhaust fan, for 2,500 AC/m at 150°C, 6" W.G. Sheldon, exhauster, size 11, type X0	2,200
		198,850
		200,000

APPENDIX C

- 1) Pilot Plant Flowsheet
- 2) Estimated Pilot Plant Development Cost

APPENDIX C

FIGURE C1 - PILOT PLANT FLOWSHEET



Approximate Operating Conditions

Feed Rate - Baghouse Dust	40 kg/Hr.
Air to Combustion Unit	15 scfm
Propane to Combustion Unit	0.52 lbs/Hr.
Fluidryer off gas volume @ 400° C	40 cfm
Cooling Air to Condenser	70 scfm
Waste Gas @ 150° C	125 cfm

Temperatures: Combustion Chamber	800 - 900° C
Fluid Bed	350 - 400° C
Hot Bag Filter	325 - 375° C
Cold Bag Filter	150° C

Table C 1 - Estimate of Pilot Plant Development Cost

1) <u>Equipment:</u>	<u>\$ Can</u>
Screw feeder with hopper (Armstrong-Jones)	7,000
Fluidizer with electrical heaters to compensate for heat losses and insulation	4,800
Hot bag filter - one bag with one spare	4,300
Condenser	2,000
Cold bag filter - 4 bags with 4 spares	2,200
Combustion unit	2,000
Exhaust fan	2,500
Miscellaneous instruments, valves etc.	<u>7,000</u>
Total equipment	31,800
Design, procurrment - 500 man hours @ \$25/Hr	12,500
Installation	<u>30,000</u>
Total	74,300
Say	75,000
2) <u>Operating Cost:</u>	
Assume: 25 weeks of operation - 5 day week	
6 men to operate - 3 shifts	
2 men for analytical and shop services	
1 professional to supervise and analyse data	
Cost: Payroll - 8 technicians @ \$500/week	100,000
- 1 professional @ \$1000/week	25,000
FML assistance - 12 man weeks @ \$1000/week	12,000
Head office assistance	12,000
Travel and other misc. expenses	<u>5,000</u>
Total operating cost	154,000
3) <u>Estimated Total Cost:</u>	
Equipment and construction cost	75,000
Operating cost	154,000
Contingency	<u>33,000</u>
Total Cost	262,000