

FALCONBRIDGE NICKEL MINES LIMITED

INTER-OFFICE MEMORANDUM

DATE: July 28, 1980

TO: H.T. Berry

COPIES TO: RAB, PHL, PGT, JFJ, FGTP, PZ/PJR
DJE (2), Kent Morton, W.A. Moore; Giant Yellowknife.

AUG - 5 1980

FROM: S.O. Fekete

SUBJECT: Arsenic Recovery at Giant Yellowknife

The alternatives for producing pure arsenic trioxide from products available at Giant Yellowknife were examined. Three alternatives were reviewed in detail, for which material and energy balances are appended, indicating that fuming with the use of electric power a mixture, consisting of wet con arsenic sludge and baghouse dust, (case A) would be the most desirable approach for the following reasons:

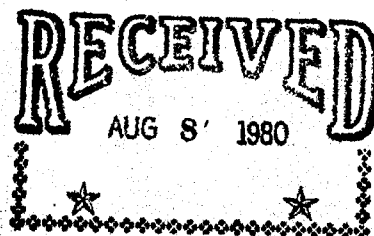
- 1) The flowsheet is very simple, involving very few unit operations, hence the capital cost would be low.
- 2) Because of the simplicity, operating cost would be expected to be low.
- 3) There is a high probability that a very pure product of high density can be produced. The risk of product contamination through the lack of operator attention would be minimal.

In contrast, case B would involve predrying the con arsenic sludge, followed by blending with baghouse dust and fuming as in case A. While this would reduce the energy cost by about 20%, the higher capital, together with higher non energy related operating costs would probably more than offset the lower expenses for energy.

Case C involves hot water leaching of a mixture of con arsenic sludge and baghouse dust. Although the approach is technically feasible as demonstrated by pilot plant work at Giant, the flowsheet is far more complex than the other alternatives, hence capital cost would be higher. Energy cost would also be about four fold of that for fuming, which could only be reduced through employing a high cost heat recovery system. In addition, a lower purity product would be produced.

Comparative energy costs for the three cases considered are estimated as follows:

...../2



	wt kg/hr	Assays wt%		
		As ₂ O ₃	inerts	water
plant feed				
baghouse dust	450	90.0	10.0	
con arsenic sludge	643	46.7	23.2	30.0
Total	1093	64.5	17.8	17.7

As₂O₃ Production: 12 x 10⁶ lbs/year @ 97.5% recovery

	Case A	Case B	Case C
Energy used (excluding motive power)			
Electric power KW Hr/lb As ₂ O ₃	0.200	0.084	-
Propane lbs/lb As ₂ O ₃	-	0.022	0.274
Energy cost c/lb As ₂ O ₃ Power @ 5¢/KWH	1.0	0.42	-
Propane @ 16.3¢/lb	0	0.36	4.47
Total	1.00	0.78	4.47

Heat transfer rates to permit sizing of the fuming furnace and condenser are the only significant process uncertainties, assuming that the operating staff can provide information on the handling characteristics of the plant feed components. FML are currently conducting preliminary tests directed towards determining heat transfer rates. Assuming that these tests will yield favourable results, it is recommended that the engineering department detail out the flowsheets and estimate capital and operating costs. Unless there are compelling reasons the hot water leaching, Case C, should be deleted from further consideration and Case B should only be considered to the extent that the water content of the con arsenic sludge is substantially higher than assumed.

If the capital and operating costs indicate favourable economics, piloting the fuming furnace and the condenser, to obtain firm design data would be necessary. The size of the pilot installation and costs associated with it, can only be estimated upon completion of some of the laboratory work, which will provide a feed for approach to be taken, the potential difficulties in handling the products and obtaining the necessary measurements.

Description of Alternatives

1) Basis

It was assumed that the facility would be designed to produce 6,000 short tons of As₂O₃. About 60% of the production would come from currently produced baghouse dust and the remainder from reclaiming and processing con arsenic sludge. Alternatively, the con arsenic sludge could be replaced with material reclaimed from underground storage, which on the basis of information on hand would be very similar in composition and handling characteristics. In either case, significant gold values in the reclaimed material would add substantially to the operating revenue, by processing the residue from the arsenic trioxide recovery plant in the existing carbon plant.

For the purposes of the material and heat balances the following were assumed:

a) Plant feed: 450 kg/oper. hr baghouse dust
 450 " dry con arsenic material
 900 " total

b) Analysis:

Product	wt kg/hr	Assays wt%			kg/hr		
		Volatile As ₂ O ₃	Inerts	Water	Volatile As ₂ O ₃	Inerts	Water
Baghouse dust	450	90.0	10.0	-	405.0	45.0	-
Con arsenic sludge	643	46.7	23.3	30	300.2	149.8	193
Total	1093	64.5	17.8	17.7	705.2	194.8	193
Residue after fuming	194.8	-	100.0	-	-	194.8	-

c) Operating Time= Assume 330 days/year 7920 oper. hrs/year

d) As₂O₃ Production:

As ₂ O ₃ in plant feed	5585.2 MT/year
As ₂ O ₃ in product	5448.0 MT/year
As ₂ O ₃ losses	137.2 MT/year
Recovery	97.5%

2) Case A (Reference: Figure A - Appendix A)

Reclaimed con arsenic sludge is fed from a surge hopper into a blender which also receives dry baghouse dust. The blend is expected to be relatively free flowing and due to about 15 to 20% contained moisture should also handle without much dusting. The blend would be forwarded to a furnace feed storage from which it would be fed at a uniform rate into an electrically heated multiple hearth furnace.

The moist blend would dry, produce water vapour which would serve as an inert carrier for the As₄O₆ vapours and also allow lower operating temperatures because of the low partial pressure of As₄O₆. The fuming furnace would be operated in the 300 to 400°C range (400°C assumed for the heat balances), discharging the residue into a closed container, from which it is removed, cooled and sent to the carbon plant for gold recovery.

The vapours leaving the fuming furnace are led into a condenser maintained at about 105 to 110°C, where As_2O_3 would condense as a coherent deposit on water cooled surfaces, while the water vapour would be exhausted to the existing baghouse or join the roaster flue system at some other point. The design of the condenser will depend on the conductivity and physical characteristics of the deposit, which requires determination by laboratory and pilot plant studies. It is expected that the condensed As_2O_3 would be dense flakes, which would be removed via a lock chamber from the condenser and conveyed to product storage and packaging.

3) Case B (Reference Figure B - Appendix B)

Case B departs from Case A in that the con arsenic sludge would be dried before it is blended with the baghouse dust, thus replacing the power used for driving off moisture with propane, resulting in a modest saving for energy cost (for the assumed power versus propane cost). It is proposed to carry out the drying of the con arsenic sludge in a rotary dryer, after which it is blended with baghouse dust and fed to the electrically heated fuming furnace. Due to the higher As_4O_6 vapour content, the fuming furnace would have to be operated near the boiling point of arsenic trioxide (450°C assumed for heat balances). A small amount of inert gas would also be needed to act as a carrier, which after passing through the condenser would be exhausted to the existing baghouse.

Condenser service would be somewhat less demanding and would probably allow application of less surface, because of the substantially higher As_4O_6 vapour content of the gases. Otherwise the system would be similar to case A.

4) Case C (Reference Figure C - Appendix C)

Con arsenic sludge and baghouse dust are fed into the first of two vessels in cascade, and contacted with hot (100°C) mother liquor from the crystallizer and wash solution from the wash thickener. The vessels would be equipped with agitators and provide a residence time of about 90 minutes. The residue would be separated in the leach thickener, then forwarded to a mixing tank where it is mixed with wash water and then thickened again. The residue from the wash thickener is pumped to the carbon plant for gold recovery, while the thickener overflow joins the mother liquor and after heating to 100°C forwarded to the first leach tank.

The pregnant solution from the leach thickener would be filtered in a clarifying filter and then forwarded to the crystallizing vessel. The crystallizer vessel equipped with an agitator would be maintained under vacuum at about 50°C. Cooling is accomplished through vapourization of water, the water vapours being exhausted by an eductor via a condenser. The condensing vapours would also be used to heat the make up water to 50°C before it is used as wash in the wash thickener.

The crystallizer magma would be discharged to a centrifuge separating the As_2O_3 crystals and mother liquor. The crystals would be dried in dryer using steam (holo-flite) and conveyed to storage and packaging. The mother liquor would be recycled via a steam operated heat exchanger to leach.

S. O. Fekete

SOF/1k

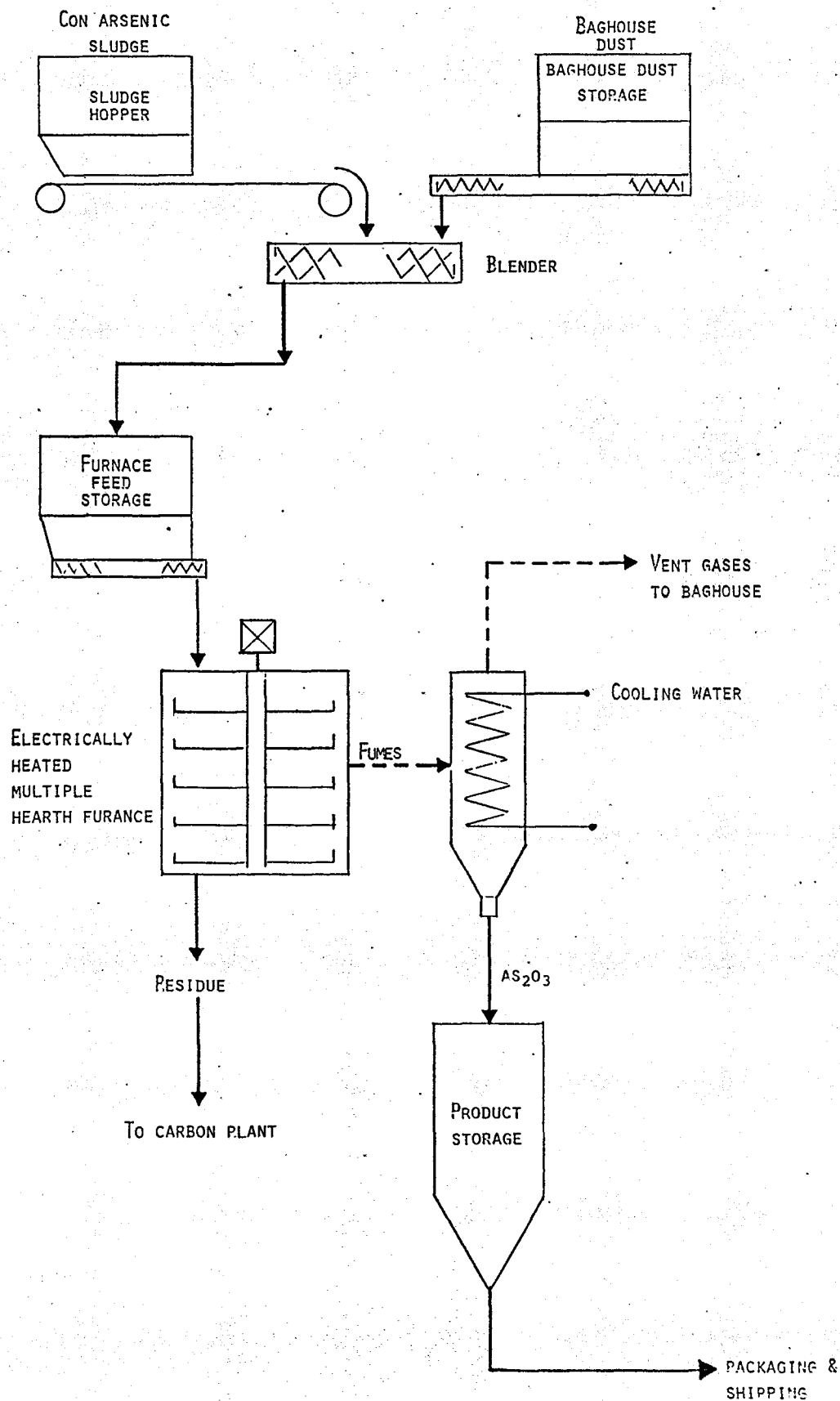
S.O. Fekete

APPENDIX A

Flowsheet, Material and Heat Balances for

Case A

FIGURE A
FLOWSHEET FOR CASE A



A) Mass and Heat Balances for Case AA-1) Fuming Furnace

	mass kg/hr	K cal's per kg	Total K cal's per hr 000's
Fuming Furnace feed @ 25¢: solids	900.0	-	-
water	193.0	-	-
Electric Power	-	-	261.00
Total input	1093.0	-	261.00
Residue after fuming @ 400°C	194.8	93.75	18.26
As ₄ O ₆ vapours: heat of volatalization	705.2	77.10	54.37
sensible heat at 400°C		22.50	15.87
Water : heat of vapourization	193.0	583.89	112.69
sensible heat at 400°C		175.1	33.79
Thermal losses	-	-	26.02
Total output	1093.0	-	261.00

A-2) Condenser Heat Balance

	Mass kg/hr	K cal's per kg	Total K cal's per hr in 000's
As ₄ O ₆ vapours: heat of volatalization	705.2	77.10	54.37
sensible heat @ 400°C		22.50	15.87
Sensible heat of water vapour @ 400°C	193.0	175.1	33.79
Total input	898.2		104.03
As ₂ O ₃ product @ 110°C	705.2	21.25	14.99
Sensible heat of water vapour @ 110°C	193.0	38.20	7.37
Heat removed by cooling water	-	-	71.67
Thermal losses	-	-	10.00
Total output	898.2		104.03

A-3) Fuming Furnace Vapour Composition and Volume

	kg/hr	kg moles/hr	Vol %
As ₄ O ₆ Vapours	705.2	1.78	14.2
Water Vapour	193.0	10.72	85.8
Total	898.2	12.50	100.0

.... /con't

A-4) Electrical Power Consumption and Cost

Electric power used:

303.4 KWhr/hr
2,403,160 KWhr/year

Cost of power: @ \$US 0.05/KWhr

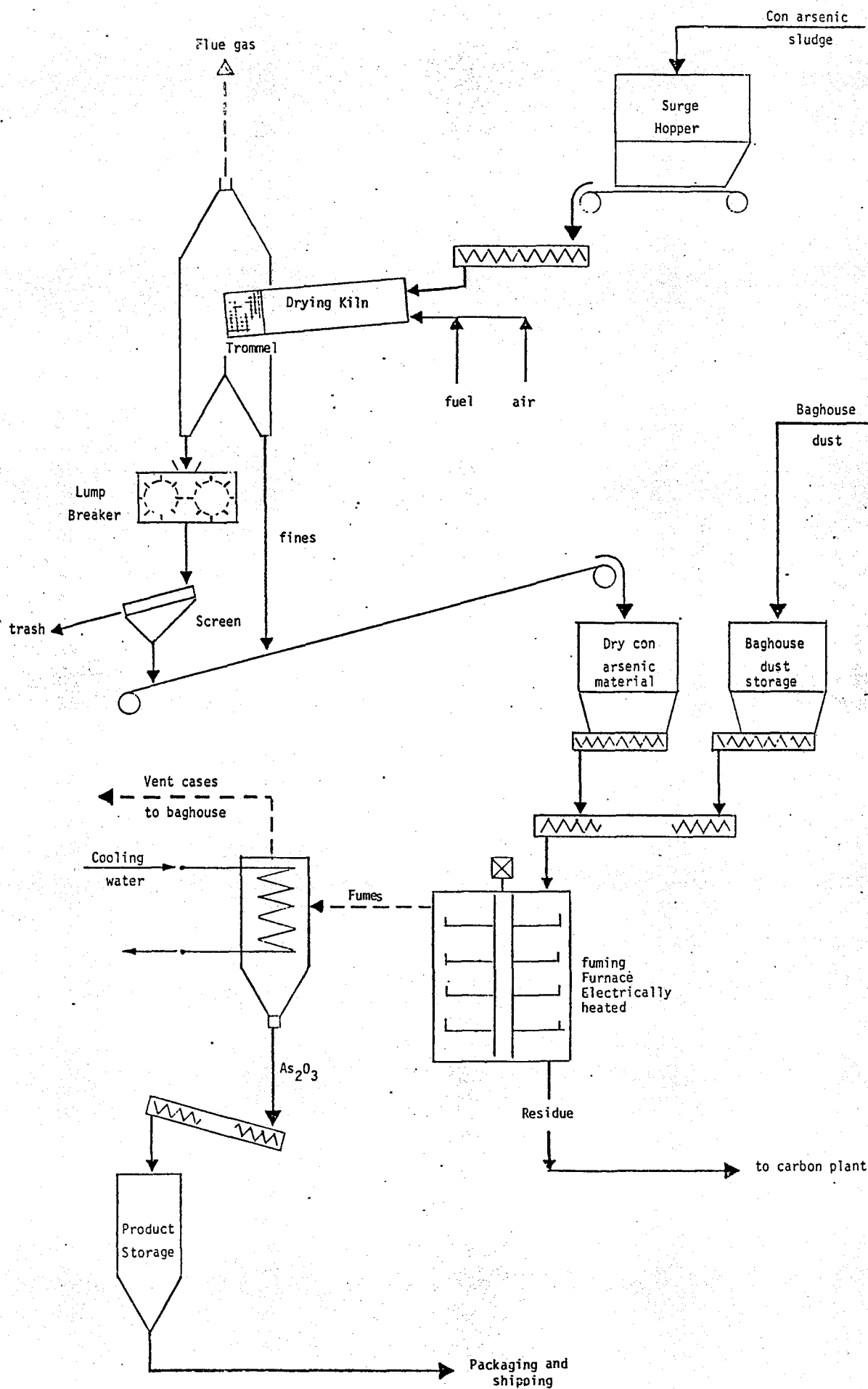
\$120,158 per year
\$ 0.022/kg As_2O_3
\$ 0.01/lb As_2O_3

APPENDIX B

Flowsheet, Material and Heat Balances for

Case B

FIGURE B
FLOWSHEET FOR CASE B



B-1) Dryer Heat Balance

	Mass Rate		Heat Effect K cal/s		Total K cal/s per hr 000's
	kg/hr	kg mole/hr	Per kg	Per kg mole	
Con arsenic sludge @ 25°C: solids	450.0	-	-	-	-
water	193.0	10.72	-	-	-
Combustion air @ 25°C			-	-	-
Propane	15.0	0.34	11,100	-	166.50
Total input					166.50
Dry con arsenic product @ 100°C	450.0	-	18.75	-	8.44
Sludge water: vapourization	193	10.72	583.89		112.69
sensible heat @ 127°C	193	10.72	45.83		8.85
Combustion gases @ 127°C: CO ₂		1.02	-	954.8	0.97
H ₂ O		1.36	-	824.9	1.12
O ₂		4.01	-	725.1	2.91
N ₂		21.48	-	710.1	15.25
Thermal losses					16.27
Total output					166.50

B-2) Dryer Flue Gas Volume

	kg/hr	kg moles/hr	Vol %
Combustion air	784.2	27.19	-
Propane	15.0	0.34	-
Sludge water	193.0	10.72	-
Total input	992.2	38.25	-
Flue gas: CO ₂	44.9	1.02	2.64
H ₂ O	217.5	12.08	31.30
O ₂	128.3	4.01	10.39
N ₂	601.5	21.48	55.67
Total output	992.2	38.59	100.00

.... /con't

B-3) Fuming Furnace Heat Balance

	Mass Rate		Heat Effect K cals		Total K cals Per hr 000's
	kg/hr	kg mole/hr	Per kg	Per kg mole	
Dry con arsenic material @ 100°C	450.0	-	18.75	-	8.44
Baghouse dust @ 25°C	450.0	-	-	-	-
Dilution water @ 25°C	10.7	-	-	-	-
Electrical power	-	-	-	-	101.56
Total input	910.7	-	-	-	110.00
Residue after fuming @ 450°C	194.8	-	93.75	-	18.26
As ₄ O ₆ vapours: heat volatalization	705.2	1.78	77.10	-	54.37
sensible heat @ 450°C	-	-	25.50	-	17.98
Dilution water vapour @ 450°C	10.7	0.59	783.89	-	8.39
Thermal losses	-	-	-	-	11.00
Total output	910.7	-	-	-	110.00

B-4) Condenser Heat Balance

	Mass Rate		Heat Effect K cals		Total K cals per hr 000's
	kg/hr	kg mole/hr	Per kg	Per kg mole	
As ₄ O ₆ vapours: heat of volatalization	705.2	1.78	77.10	-	54.37
sensible heat @ 450°C	-	-	25.50	-	17.98
Sensible heat of diluting water vapours @ 450°C	10.7	0.59	200.00	-	2.14
Total input	715.9	-	-	-	74.49
As ₂ O ₃ product @ 110°C	705.2	1.78	21.25	-	14.99
Sensible heat of water vapour @ 110°C	10.7	0.59	38.20	-	0.41
Heat removed by cooling water	-	-	-	-	51.59
Heat losses	-	-	-	-	7.50
Total output	715.9	-	-	-	74.49

B-5) Fuming Furnace Vapour Composition and Volume

	kg/hr	kg moles/hr	Vol %
As ₄ O ₆ vapours	705.2	1.78	75.1
water vapour	10.7	0.59	24.9
Total	715.9	2.37	100.0

.... /con't

B-6) Energy Consumption and Cost

Electric power used: 127.9 KWhr/hr or 1,012,960 KWhr/year

Propane used : 15.0 kg/hr or 118,800 kg/year

Cost of power @ \$US 0.05/KWhr \$US 50,648 per year

Cost of propane @ \$US 360.00/M ton \$US 42,768 per year

Total energy cost \$US 93,416 " "

\$US 0.017/kg As_2O_3

\$US 0.078/lb As_2O_3

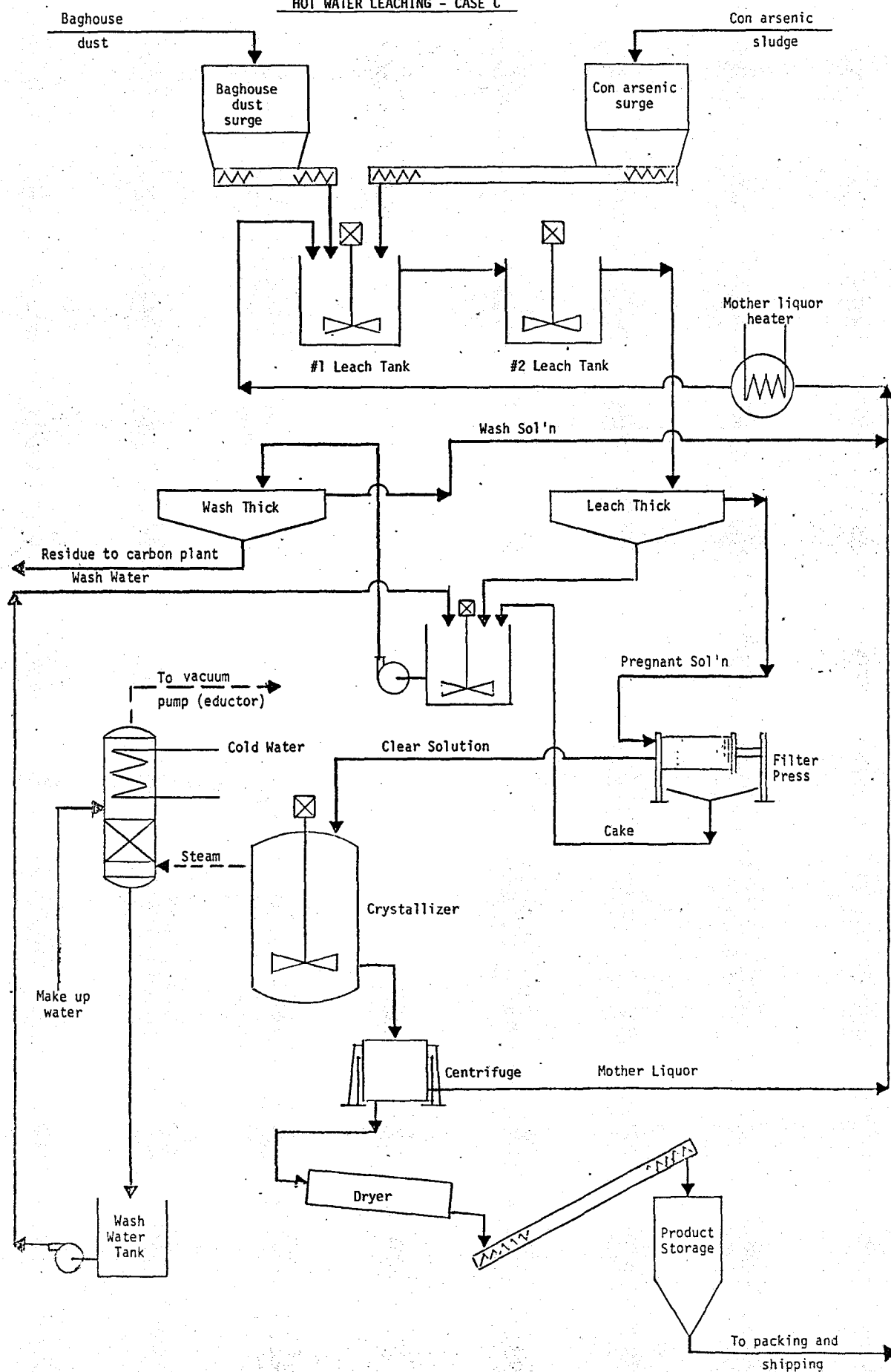
APPENDIX C

Flowsheet, Material and Heat Balance for

Case C

FIGURE C

FLWSHEET FOR As_2O_3 RECOVERY BY
HOT WATER LEACHING - CASE C



C-1) Mass Balance for As_2O_3 Recovery by Hot Water Leaching - Case C

	Analyses wt%				kg/hr		
	Total kg/hr	Inert Solids	Water	Soluble As_2O_3	Inert Solids	Water	Soluble As_2O_3
<u>Leaching Circuit</u>							
Baghouse dust	450.0	10.0	-	90.0	45.0	-	405.0
Con arsenic sludge	643.0	23.3	30.0	46.7	149.8	193.0	300.2
Mother liquor	22690.0	-	96.96	3.04	-	22000.0	690.0
Wash thick O/F	2081.6	-	98.96	1.04	-	2060.0	21.6
Total input	25864.6				194.8	24253.0	1416.8
Pregnant sol'n	25189.3	-	94.48	5.52	-	23799.0	1390.3
Leach thick U/F: solids	194.8	100.0	-	-	194.8	-	-
sol'n	480.5	-	94.48	5.52	-	454.0	26.5
Total output	25864.6				194.8	24253.0	1416.8
<u>Wash Thickener</u>							
Leach thick: solids	194.8	100.0	-	-	194.8	-	-
sol'n	480.5	-	94.48	5.52	-	454.0	26.5
Wash water	2060.0	-	100.0	-	-	2060.0	-
Total input	2735.3				194.8	2514.0	26.5
Wash thick O/F	2081.6	-	98.96	1.04	-	2060.0	21.6
Wash thick U/F: solids	194.8	100.0	-	-	194.8	-	-
sol'n	458.9	-			-	454.0	4.9
Total output	2735.3				194.8	2514.0	26.5
<u>Crystallizer</u>							
Pregnant solution	25189.3	-	94.48	5.52	-	23799.0	1390.3
Mother liquor	22690.0	-	96.96	3.04	-	22000.0	690.0
Wet crystals	737.3	-	95.00	5.00	-	37.0	700.3
Water vapour	1762.0	-	100.0	-	-	1762.0	-
Total output	25189.3					23799.0	1390.3

...../con't

C-2) Heat Balance for As_2O_3 Recovery by Hot Water Leaching - Case C

	kg/hr	K cal/kg	Total K cals/hr 000's
<u>1) Leach Circuit</u>			
Mother liquor @ 50°C : water	22,000.0	25.0	550.00
As_2O_3 in sol'n	690.0	6.25	4.31
Wash thickener O/F @ 50°C : water	2060.0	25.0	51.50
As_2O_3 in sol'n	21.6	6.25	0.14
Con arsenic sludge @ 25°C : water	193.0	-	-
solids..	450.0	-	-
Baghouse dust @ 25°C	450.0	-	-
Mother liquor heater	-	-	1203.05
Total input	25864.6		1809.00
Pregnant sol'n @ 95°C : water	23799.0	70.0	1665.93
As_2O_3 in sol'n	1390.3	17.5	24.33
Leach thick U/F @ 95°C : water	454.0	70.0	31.78
As_2O_3 in sol'n	26.5	17.5	0.46
Inert solids	194.8	17.5	3.41
Heat losses	-	-	83.09
Total output	25,864.6		1809.00
<u>2) Crystallizer</u>			
Pregnant sol'n @ 95°C : water	23,799.0	70.0	1665.93
As_2O_3 in sol'n	1390.3	17.5	24.33
Total input	25,189.3		1690.26
Mother liquor @ 50°C : water	22,000.0	25.0	550.00
As_2O_3 in sol'n	690.0	6.25	4.31
As_2O_3 crystals @ 50°C : dry crystals	700.3	6.25	4.38
crystal moisture	37.0	25.0	0.93
Water vapour	1762.0	592.9	1044.69
Heat losses	-	-	85.95
Total output	25189.3	-	1690.26

.... /con't

Unit cost for energy: \$ 98.76 / MT As_2O_3
\$ 0.099 / kg As_2O_3
\$ 0.045 / lb As_2O_3