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Memo to : K. Morton
From : R.Hatch
Subject : Canada - NWT Mineral Development Agreement
MDA Contract 265478
Giant Yellowknife Arsenic Purification Pilot Plant
Draft of Final Report on Phase 1 of the Project

April 3, 1990

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This report covers the work completed to the end of March 1990 which includes Phase 1 of the project and constitutes completion of the service contract 265478 .

During the period of this contract close contact has been kept with the Scientific Authority (J.Skeaff) and the Minerals Manager ,Dept. Minerals and Petroleum Resources (GNWT).A visit was made to Giant Yellowknife Mines in March to review the project.

The metallurgical flowsheet for the arsenic purification pilot plant is shown in Figure 1. The pilot plant process is based on the treatment of 15 ACFM of gas from the Cottrell containing gaseous As4O6 and inert particulates.Provision is made for the introduction of inerts representative of the higher inert loading associated with the treatment of impure stockpiled As2O3.Inerts are filtered on a hot metal filter and the gaseous As4O6 is condensed by air cooling to 110 deg. C. The condensed As2O3 is collected in a baghouse and the gas is vented to the existing plant baghouse and flue system. Provision is made for recycling condensed As2O3 to the condenser inlet to determine recycle effect on product particle size and antimony behavior.

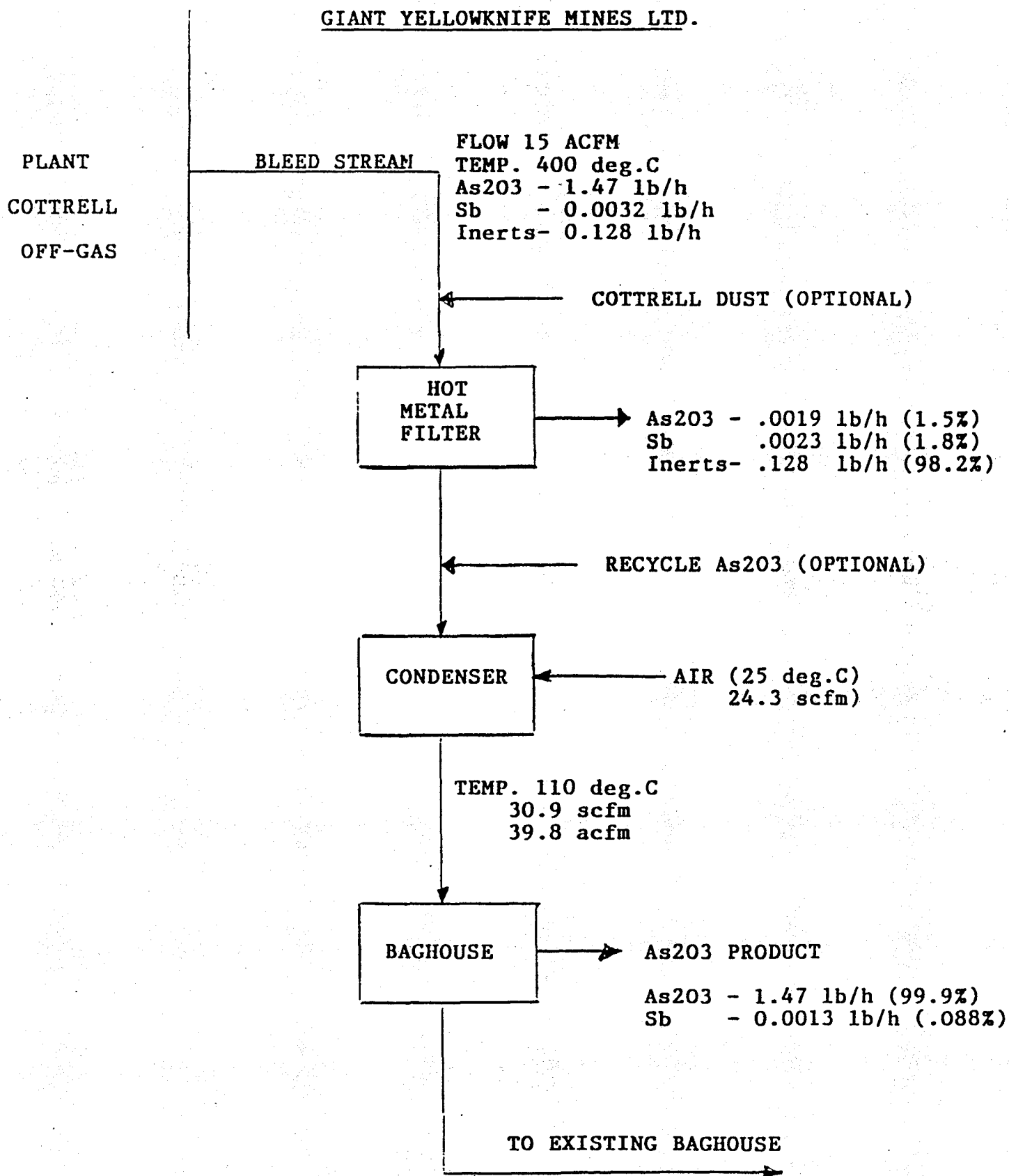
The mechanical flow diagram for the pilot plant is shown in Figure 2. All major pieces of equipment have been designed and sized. The hot filter assembly has been designed in house and contains three tubular elements. The cyclone condenser and cold baghouse have been refurbished and installed .Some piping and instrumentation has been carried out and is continuing as equipment is delivered. Purchase orders have been placed for all major equipment including filter elements, heaters, solids feeder, blower etc.

The pilot plant design and installation is on schedule as outlined for Phase 1 in our proposed schedule of Feb. 13, 1990. An invoice is attached covering 75% of the costs up to March 31, 1990.

ARSENIC PURIFICATION PILOT PLANT

FIGURE 1

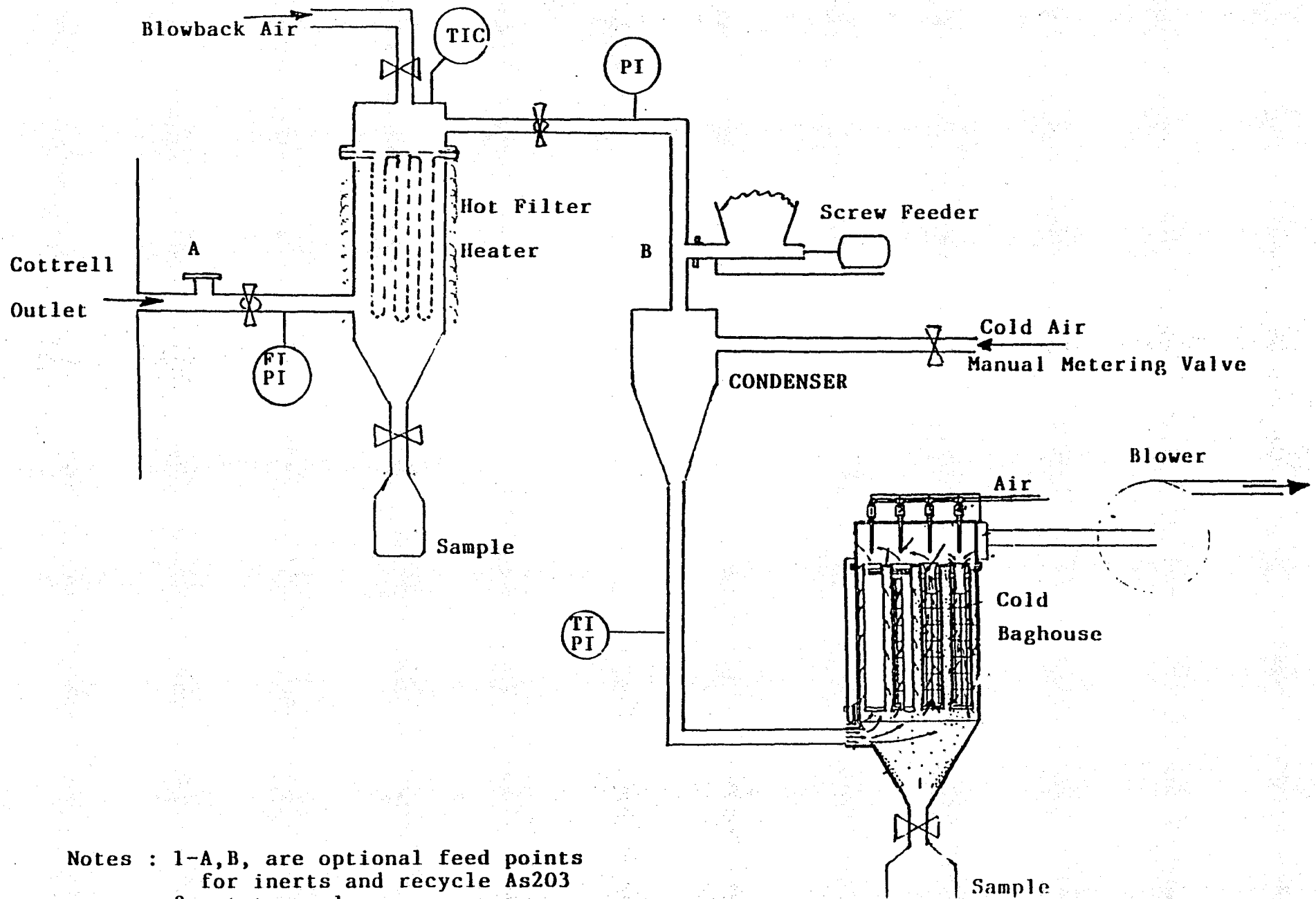
GIANT YELLOWKNIFE MINES LTD.



GIANT YELLOWKNIFE ARSENIC PURIFICATION PLANT

FIGURE 2

MECHANICAL DIAGRAM



Notes : 1-A,B, are optional feed points
for inerts and recycle As₂O₃
2-not to scale

Appendix D

Full Scale Application

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 As_2O_3 to a fluosolids reactor operating at 450°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°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°C . Additional tests were required, and a pilot plant is currently under construction to further test hot gas filtration. Concepts regarding antimony elimination and As_2O_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 As_2O_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 (As_2O_3) and (2) arsenic from underground stockpile material.

The crude As_2O_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°C to 370°C . The gas stream, enriched in As_2O_3 and reduced in volume flow is passed through a hot filter to remove Fe_2O_3 and inert solids. The filter off-gas is mixed with ambient air to obtain condensation of the arsenic at 110°C . High purity As_2O_3 is collected in a baghouse (existing) and discharged to a briquetting and flaking process. Final WAROX product is drummed for shipment.

Features of the proposed process include:

1. Utilization of roaster off-gas heat to sublime the crude As_2O_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 As_2O_3 can be shut off and downstream cooling air adjusted to accommodate the higher temperature.
5. Increased concentration of As_2O_3 and SO_2 in the gas streams. The effect of this in terms of As_2O_3 crystal size and 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 As_2O_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 As_2O_3 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 As_2O_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 As_2O_3 is given in table I. A temperature of 370° C can contain over 8000 g/m³ As_2O_3 . Condensation of As_2O_3 from a gas stream containing 59.0 g/m³ will begin at about 230° C.

Hot Gas Filtration

Roaster off-gas, inerts and gaseous As_2O_3 from the vaporization reactor pass into the high temperature sintered metal filter. Fine inert solids are retained on the filter and gaseous As_2O_3 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 1, 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).

VAPOUR PRESSURE - TEMPERATURE RELATIONSHIP FOR As406

| Temp. (c) | Temp(k) | log p | As406 p(mm Hg) | As406 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 $\log P(\text{atm})(\text{As406}) = - 6080.6/T(\text{deg K}) + 9.9506$

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

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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 Fe2O3 33622.64 cal/kg dust

Heat required to sublime As2O3

Heat of Sublimation of As2O3 15.25 kcal/mole As2O3

Heat Required for Sublimation 38510.10 cal/kg feed

Total heat required per kg crude dust

As2O3 27815.95

Fe2O3 33622.64

As2O3 sub 38510.10

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