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TRIP REPORT K-25 PLANT

Chemical Development Sub-Section
Separations Technology Section
ENGINEERING DEPARTMENT
HANFORD ATOMIC PRODUCTS OPERATION

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TRIP REPORT K-25 PLANT

INTRODUCTION

A visit was made to Oak Ridge for conferences with K-25 personnel regarding the results of recent pilot plant runs on UO_3 produced in the sixteen-inch-diameter by eight-foot-long continuous denitration unit. The data and their implications with regard to full-scale plant operation were discussed with the following persons at K-25: D. M. Lang, R. Levin, S. H. Smiley, D. C. Brater, Chas. Littlefield, H. Bernhardt, K. Rapp, E. J. Barber, J. Fox, W. Harris, P. Vanstrum, and A. P. Huber.

Following these discussions, a tour was made through the diffusion plant in company with Chas. Littlefield and through the feed plant in company with Ben Thompson.

SUMMARY

Pilot Plant Performance Data

Two lots of UO_3 powder, produced in the 321 Building, sixteen-inch-diameter continuous calciner, were sent to K-25 for pilot plant evaluation. Test data for these lots, along with representative pilot plant and production plant operating data using pot calcined source feed, are presented in Table I. Highlights of information from these data are:

(1)

(2)

(3)

(4)

(5)

[redacted]

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(6) Pilot plant data for either sulfated or unsulfated pot powder show superior conversion at higher rates than for continuous calciner produced powder.

(7) Production plant data, included for comparison, show the generally expected performance for UO_3 powders.

Production Plant Data

(1) Present plant equipment includes both vibrating trays and screw agitated reactors. Product from these is fed to conversion towers where UF_4 is burned to UF_6 with fluorine gas.

(2) Installed capacity at Paducah and Oak Ridge is thirty-six tons of uranium/day using UO_3 comparable to H.A.P.O. and S.R.P. product. In view of present commitments, this full capacity will not be utilized before fiscal 1960.

(3) Operation at 75% of present production rates and with lowered conversion to UF_4 would require start-up of additional installed equipment in fiscal 1957 and addition of a minimum of one complete feed line by fiscal 1958.

(4) Average costs for present type operation are \$948/ton of uranium, including \$788 for operation and \$160 for equipment amortization. At lower rates and lower conversion, these values could increase to \$892 for operation and \$187 for amortization, a gross of \$1079/ton.

Laboratory Data

(1)

(2)

DISCUSSION

Pilot Plant Data

It was concluded by K-25 pilot plant personnel that several factors of importance to production plant processing are implied by the test data. These factors are:

(1) Considering the performance of the continuously-produced test powders in the pilot plant as being applicable to prediction of

production plant performance, the following rates and percentage conversions may be expected in screw lines:

90 percent reduction and 80 percent hydrofluorination at 3 T/D.
98 percent reduction and 95 percent hydrofluorination at 1.8 T/D.

(2) At 3 T/D rates, the addition of equipment and extra operating costs due to the lower efficiency of the process, will result in about $95 per ton increase in unit costs. The $95 per ton incremental unit cost increase does not include any screw replacement costs, at $5000 per screw plus down time, at greater than present frequency in case of sulfur initiated failure.

Production Plant Operation

Capacity

Installed equipment, estimated to give a capacity of thirty-six tons of uranium per day from UO_3 to UF_4 includes the following:

Paducah, Kentucky (C-Ky)

3 Lines to give 8 T/D (at 95 percent UF_4)

4 Lines to give 16 T/D (at 95 percent UF_4)

Oak Ridge, Tennessee (K-25)

3 Lines to give 12 T/D (at 95 percent UF_4)
One reduction tray as above, followed by three cascaded hydrofluorination screw reactors, as above.

Standard Operation (98 percent reduction, 95 percent UF_4 conversion)

Powder is moved from the feed to the product end by displacement on the vibrating tray.

[redacted]

Reduction, in screw reactors, is accomplished under the same conditions of temperature and gas flow as in the trays. Powder is moved from the feed to the product end by displacement.

Effect of Process Variables

Reduction

Hydrofluorination Operation

The UO_2 supplied to the hydrofluorination operation from the previous reduction step is affected by all prior process conditions. The main criterion for determining the degree of conversion to UF_4, all other things being equal, is the specific surface area of the UO_2.

Fluorination. This reaction, although of itself a simple combination of gaseous fluorine with dry, powdered feed, depends to a large extent on the uniformity of the UF_4 supplied. The major effect of low conversion efficiency from UO_3 to UF_4 on costs is a matter of stoichiometry. The effects of variable composition and physical properties on the operation of the fluorination towers may be significant and some of these effects are summarized below:

Large Particle Size. The UF_4 supplied to the fluorination tower will, in general, have about the same particle size distribution as the UO_2 originally supplied to the reduction steps.

[redacted]

Optimization of Process

Using the present gaseous diffusion feed plant equipment and process conditions, an ideal powder would reduce, hydrofluorinate, and undergo conversion to UF_6 essentially quantitatively.

[redacted]

Cost Information

Basis for Cost Data

1. Present cost, for pot powder, is based on 96 to 98 percent reduction and 95 percent conversion to UF_4 prior to fluorination, giving four tons of uranium per day per screw line, and 2-2/3 tons of uranium per tray line.
2. A new line costs $300,000 purchase cost plus $700,000 installation cost for an installed cost of $1,000,000.
3. A standard operating cost is $140,000 per year per line.

4. Amortization is based on five-year replacement, or $200,000 per operating year per operating line.

5. Operating cost increases, due to lowered conversion efficiencies, reflect primarily the increased cost of fluorine and the number of lines required to meet process commitments.

6. 450 tons of uranium per month from continuous calciners, starting in fiscal 1957, require 5 screw lines at 3 T/D per line.

7. A four-year period, fiscal 1957 through fiscal 1960, is considered, assuming no change in costs of processing pot powder, and scheduling only the minimum equipment actually needed.

Using present cost estimates and production commitments for H.A.P.O., Paducah, and K-25, comparative costs have been summarized for several possible performance characteristics. The idealized case, where exact stoichiometric relationships exist among the reactants, represents the optimum target for the process employed. The present experience, used as a basis for projected costs, is with pot-calcined powder from H.A.P.O. and S.R.P. Case I and Case II are for 450 tons of U per month as continuously-produced UO_3, giving 90 percent reduction and conversions to 80 and 72 percent U in UF_4, respectively, which requires 5 screw lines at 3 tons of uranium per line per day.

COST SUMMARY TABLE

Case	Percent Conversion		Fluorination Feed Percent U in			Fluorine		Costs, $/Ton			
	UO_3 to UO_2	UO_2 to UF_4	UF_4	UO_2	UO_2F_2	Lb. / Ton U	$ / Ton U	Oper.	Amort.	Total	Change
Ideal	100	100	100	---	---	319	240	---	---	---	---
Present	98	95	93	5	2	401	301	788	160	948	0
I	90	89	80	10	10	543	407	856	187	1043	+95
II	90	80	72	18	10	645	484	892	187	1079	+131

K-25 Laboratory Data

(1) Effect of Pre-heat Followed by Flash Calcination

(2) Calcination Rate Studies

(3) Electron Microscopy

Using a silica replica technique, surface characteristics of numerous types of UO_3 have been observed at 10,000 to 20,000 diameters magnification. Interesting differences between samples are observed, but so far, it has not been possible to correlate these with reactivity.

(4) Reduction and Hydrofluorination

An attempt is to be made to evaluate the temperature rise due to the exothermic reactions of reduction and hydrofluorination. This is to be accomplished by employing two samples simultaneously, one for temperature measurements, and one for weight change measurements. These data should shed light on the sintering and caking phenomena observed in plant reduction and hydrofluorination reactors.

VISIT TO X-10

Persons contacted at X-10 included F. L. Culler, F. Bruce, J. Flannery, J. E. Savolainen, R. C. Wymer, D. Foster, W. Lewis, R. Wischow, T. McDuffie, K. Jackson, and M. A. Turner.

Solvent Stability

For solvent stability tests, a special Naphtha #1 was obtained from AMSCo which contained less than 1 percent unsaturates and aromatics. This was further purified by sulfonation. With 6 percent TBP in the diluent, no radiation effect could be detected using a Cobalt 60 source and five cycles of extraction and stripping (Thorex feed: 1.8 M.ANN, 3.8 g/l U, 0.1 M.HNO_3, 0.005 M. Hg $(NO_3)_2$). The dose rate was 0.7 watt hr./liter of solvent per cycle for a total dose of 3.5 watt hours.

Test for Unsaturates with Chromyl Chloride

Chromyl chloride is a sensitive reagent for detection and determination of unsaturates. Differences of 0.005 percent olefins may be determined. Hindered olefins react as do some cyclic hydrocarbons.

Slug Dissolution Studies

The derivation and method of application of rate equations applicable to column dissolution studies and detailed results of continuous dissolver runs were obtained and have been transmitted to the Process Studies Group. These data indicate that continuous dissolver operation will permit of higher rates than present batch methods.

UF_4 Production

[1]Detailed data for runs made during April 1955 were furnished the authors.

TABLE I

PILOT PLANT PERFORMANCE DATA