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PUREX PHASE II PROPOSED FLOWSHEET

By

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Purex Technology Operation
Research and Engineering
CHEMICAL PROCESSING DEPARTMENT

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February 1, 1957

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Operated for the Atomic Energy Commission by the General
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I. Introduction

The excellent decontamination performance of the present Purex organic-continuous 2D Column has given impetus to the concept of a two cycle Purex Plant. It is now believed that installation of an organic-continuous HA Column plus certain flowsheet improvements, will put the two cycle process well within our grasp. The increased capacity, flexibility, and lower unit costs furnish the incentive for an early Phase II conversion. This study flowsheet has been prepared for comment, preliminary equipment design studies, and to point out areas requiring further laboratory and cold semiworks testing.

It is not expected that all the innovations incorporated in this flowsheet will be accomplished at one time; conversely, additional changes which will improve the flowsheet performance will probably be forthcoming periodically.

II. Summary

1. A Purex Phase II two-cycle flowsheet has been designed to permit attainment of a Purex processing capacity factor of at least 4.0 with a minimum investment in new equipment and a maximum assurance of success.
2. Major equipment requirements to attain a capacity factor of 4.0, using the new flowsheet, are as follows:
 - (a) Six new or modified extraction columns (assuming a new HA Column installation prior to Phase II conversion). Several of the column changes may be only cartridge changes.
 - (b) Charging chutes are required on the dissolvers to attain capacity factors in excess of 3.7.
 - (c) All other major equipment pieces are adequate.
3. Savings resulting from adoption of Purex Phase II two-cycle operation are as follows:
 - (a) Capital investment savings (elimination of new equipment pieces)
 - (1) T-F5 Acid Absorber \$395,000
 - (2) First Cycle Organic Treatment System 300,000
 - (b) Operational savings
 - (1) Overall plant plutonium and uranium losses reduced by factors of three and two, respectively.
 - (2) A thirty per cent reduction in essential material costs.
 - (3) A factor of three reduction in waste storage charges.

(c) Other savings

- (1) Routine fractionation and overall plant use of UO_3 recovered acid.
- (2) A significant reduction in the total water and activity discharged to the ground.
- (3) Approximately a thirty per cent reduction in the SS material plant inventory.

III. DiscussionA. Basis

The primary bases of the proposed Purex Phase II Chemical Flowsheet are two solvent extraction cycles followed by an ion exchange plutonium tail-end step and possibly a silica gel uranium finishing operation. The proposed process makes extensive use of waste and organic backcycle to attain lower unit costs, greater assurance of adequate decontamination, and process flexibility. The flowsheet design is necessarily in part developed around existing plant equipment and layout. As a result of flowsheet adjustments, which increased the processing capacity of existing equipment without seriously affecting performance or economics, Phase II conversion costs are greatly reduced.

A number of long range flowsheet improvements believed desirable and feasible have purposely been excluded in order to remain within the bounds of known technology. In those cases where the flowsheet has departed from known technology, sufficient time appears to be available prior to the Phase II requirement to permit these technological questions to be answered. In all cases, the questionable areas are sufficiently small so that major flowsheet revisions, which might affect long range planning, will not be required.

The processing capacity target set for this flowsheet is a $\text{CF} = 4.0$. It is recognized that design studies may indicate the goal should be reduced to ca. $\text{CF} = 3.5$ in order to achieve maximum processing rates at minimum costs. Flow basis is the same as for HW No. 3 Flowsheet⁽¹⁾ (100 flows = 747 gal. uranium) except for a decrease in HAF flow to 75 with a corresponding increase in HAF uranium concentration.

B. Factors Affecting Decontamination and Product Quality

The revised cartridge, bottom-interface 2D Column installed in the Purex Plant during November 1956, has given outstanding performance.⁽²⁾ The improvement in decontamination over the performance of the standard cartridge, top-interface column is attributed to two factors:

- (1) The interface has been placed at the waste rather than at the product end of the column, thus reducing carry-over of high-activity particulate matter and the sensitivity of the process to upsets.

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(Since the new column has been installed, no product batch has exceeded gamma specification despite "normal" upsets due to power outages, instrument failures, or start-up conditions.)

- (2) The "Zebra" cartridge scrub section apparently provides exhaustive scrubbing by: (a) the high degree of agitation achieved, (b) the elimination of backmixing by banding action, and (c) possibly by a higher organic phase residence time.

Although the individual contributions from each of these factors have not been determined, the decontamination factor improvement over the old 2D Column ranges from ten to twenty. The application of similar techniques to the first solvent extraction cycle can reasonably be expected to yield similar gains in performance, although possibly not as spectacular.

In order to provide additional assurance of acceptable decontamination, several other factors have been built into the process. Only those changes from the existing plant flowsheet are discussed below: ④

- (1) The present HC Column is converted into an additional scrub section (HS Column), operated with bottom interface. This column doubles the present scrub section length and provides essentially exhaustive scrubbing.
- (2) A high acid, high uranium saturation HA Column extraction section is provided in the flowsheet. The high acidity utilizes Backcycle Acid (3WB) and is designed to insure adequate ruthenium decontamination since ruthenium could well become a major contributor to product contamination in a two cycle process utilizing low acid final cycles. The high (75 per cent) organic phase uranium saturation at the feed plate is intended to provide a good start on zirconium-niobium decontamination.
- (3) The HA scrub section and the HS scrub column are operated at relatively low acidity and low uranium saturation (63.2 per cent) primarily for zirconium-niobium decontamination. Chemical Research data⁽⁴⁾ have shown that the scrub section zirconium DF is dramatically and adversely affected by high uranium saturation of the organic phase in the scrub section. Low uranium saturation also provides the following benefits: (a) furnishes sufficient specific gravity difference in the HS and IBX Columns for proper operation, (b) permits introduction of IBSU backcycle for additional scrubbing, and (c) improves plutonium decontamination from UX₁ in IBX Column operation.
- (4) Plant experience indicates that the IBSU stream may be highly contaminated. Backcycle of IBSU to the HA Column rather than

processing in the IBX Column provides additional scrubbing of this stream as well as part of the uranium dilution desired in the HA scrub operation.

- (5) The IBS Column is operated under acid conditions considerably higher than in previous flowsheets. Although the purpose of adding acid to the IBXP stream is to permit the use of uranium contaminated UO_3 acid in the Final Plutonium Cycle by eliminating direct 2AF Tank nitric acid addition, a somewhat increased plutonium decontamination from zirconium, niobium and UX_1 is expected. Since the IBSU is backcycled to the HS Column for scrubbing, no loss in uranium decontamination due to a high acid IBS Column should result.
- (6) The IBX acidity has been increased from 0.1 M to 0.5 M to aid UX_1 decontamination.
- (7) The process in general is operated at 40-50°C for improved zirconium, niobium and ruthenium decontamination. Although the effect is probably greater on ruthenium, plant experience has also indicated increased Zr-Nb DF at elevated temperatures.
- (8) The ion exchange tail-end decontamination and concentration process has been chosen for plutonium. The fission product decontamination factor is expected to range from five to ten. Corrosion products and uranium contamination will also be reduced.
- (9) Backcycle of second cycle wastes permits operation of the final cycles for maximum decontamination rather than for the conflicting demand of maximum product recovery. For example, an ultra low-acid Final Plutonium Cycle flowsheet which would give greater decontamination is currently being investigated in the laboratories, but would not be suitable without waste backcycle because of the high plutonium waste loss. The Phase II flowsheet does not involve excessive (> 0.1 per cent) Final Plutonium Cycle losses but greater flexibility is made possible by waste backcycle.

C. Factors Affecting Product Recovery

Under the proposed flowsheet conditions, the only plutonium losses from the plant are in the coating waste, HAW, and 2BW streams. Similarly, uranium losses are restricted to coating waste, HAW, ICW and 2EW. All other waste streams (HCW, IAW, 2DW, 2AW and XAW) are backcycled or eliminated. In addition all plutonium bearing streams are chemically stripped (Fe^{++} in IBX and hydroxylamine sulfate or other reductant in the 2B Column) to reduce losses. Any plutonium loss to the IBU is recovered by 2DW backcycle. Total plutonium extraction waste losses are expected to be reduced by at least six-fold.

D. Capacity and Equipment Utilization Factors

Under the proposed flowsheet a number of capacity gains and equipment economies are possible. For purposes of brevity, major equipment items and their application considerations are listed in Table I. No detailed study of smaller equipment items such as valves, rotameters, or jumpers has been made as yet. "Fixed" routings have been briefly examined for feasibility and no major problems found. A simplified flow diagram is shown in Figure I.

E. Impact Upon Other CPD Facilities

(1) UO₃ Plant

⊙ The proposed flowsheet makes possible the use of UO₃ recovered nitric acid throughout the Purex Plant. At the present time, UO₃ recovered acid cannot be used for the 2AF Tank nitric acid addition because uranium contamination of the plutonium would result. By adding recovered acid to the IBXP stream the uranium is stripped in the IBS Column, the acid in the IBP equals the required 2AF acid concentration, and acid addition to the 2AF Tank can be eliminated. Thus, UO₃ recovered acid can be combined with Purex recovered acid and fractionated to 60 weight per cent prior to its use in the Purex Plant. Consequently, the UO₃ Plant can decrease the concentration of the recovered acid from 50 to 40 weight per cent and recover 1000 pounds of ⊙ acid per ton of uranium processed instead of only 850 to 900 pounds. However, UO₃ Plant recovered acid must still be used separately in the 2DIS stream because the gamma activity in Purex recovered acid is excessive for this application.

Table II summarizes a preliminary Purex-UO₃ Plant acid balance.

(2) Z Plant

Two choices of plutonium product are available for shipment from the Purex Plant under the proposed flowsheet:

- (a) Ion exchange product (50-60 g Pu(III)/l, ca. 5 M HNO₃, 0.3-0.4 M NH₂SO₃H or other holding reductant), shipped directly, would provide maximum product purity and would very likely be ideally suited to a continuous Pu(III) oxalate or PuF₃ Task I, II operation. An evaluation of this material as feed to the oxalate Continuous Task I should also be made from the standpoint of capacity. If a Task I or I & II installation were made at Purex, direct processing of ion exchange product should definitely be considered.

- (b) Shipment of concentrated product (100 to 150 g Pu(IV) & (VI)/l) comparable to the present Purex product necessitates installation of an evaporator at Purex. Such a concentration step would undoubtedly add undesirable contaminants unless glass lined or other highly corrosion resistant materials of construction were chosen.

It is suggested that direct processing of ion exchange product be actively investigated at the earliest possible date.

F. Economic Incentive

The principal economic incentives for two cycle operation are: (a) reduced capital investment for higher capacity, (b) increased product recovery, (c) reduced waste storage costs, and (d) reduced essential materials costs. Major unit processing costs (manpower and overhead) will remain essentially unchanged. Although some manpower savings might be possible under the proposed flowsheet, the same number of equipment pieces as before must be operated and maintained. A somewhat intangible saving can be placed on improved product quality which in the case of plutonium results from ion exchange processing.

Possibly the major incentive lies in the attainment of higher processing capacity with a minimum of capital investment. Under the proposed Phase II flowsheet, a maximum of six extraction columns (including the new HA Column to be installed in the near future) must be replaced to attain a capacity factor of 4.0. In at least two cases out of the six (HS and IBX Columns) only a cartridge change may be necessary. In addition, the need for the following new equipment is eliminated: (a) Acid Absorber T-F5 (\$350,000), (b) a new First Cycle Organic Treatment System (ca. \$300,000), and (c) a remote L Cell Plutonium Concentration Package (\$500,000). However, ion exchange facilities will be required for plutonium concentration and purification.

Waste storage requirements are reduced so as to extend the useful life of the 241-A Tank Farm by at least a factor of two. On this basis early construction of a 241-AX Farm is not required.(7) Table III summarizes the 241-A Waste Storage outlook under several different assumptions.

Elimination of the HCP Concentrator and the Plutonium Concentrator will reduce the inventory of SS materials by thirty per cent.

The present hydrological condition affecting disposal of Purex low activity wastes to ground will be considerably alleviated under the proposed flowsheet. Process condensate (A5 Crib) and steam condensate (A6 Crib) flow ratios can be reduced by factors of about 1.7 and 1.2, respectively. In addition, the amount of activity entrained in overheads from the uranium concentrators is expected to be considerably reduced due to the higher solvent extraction decontamination factors attained prior to the first concentration step.

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Table IV presents a summary of unit processing cost under the present and proposed Phase II flowsheets.

G. Problems Requiring Study

A considerable amount of development effort will be required to realize the full potential of the two cycle flowsheet. A portion of this effort is already underway, and it is anticipated that other portions will be initiated by the appropriate organizations through liaison with Purex Technology personnel. Problems requiring study are outlined below.

(1) Laboratory Development

- (a) The HA-HS Column flowsheet should be optimized as to acidity, saturation and stagewise location of backcycle introduction (3WB, IBSU-HAO). Both full activity level Mini, and spiked Profile column work should be done.
- (b) Following optimization of the HA-HS system, the First Cycle flowsheet should be tested in toto for fission product partitioning and overall performance information.
- (c) Development effort now underway on an "ultra low" acid final plutonium cycle should continue.
- (d) Plutonium ion exchange development work should continue both on the cation and anion plutonium concentration tail-end processes and the IWW anion exchange plutonium recovery process.
- (e) Methods for ground disposal of the carbonate IOW and 20W streams should be actively investigated. Table III indicates considerable savings are to be gained in waste storage costs if ground disposal of carbonate solutions is possible.
- (f) A study should be made of IWW neutralization and self-concentration characteristics with particular reference to the high iron (and aluminum) content.
- (g) Improved methods of solvent treatment should have continued study.
- (h) Alternate diluent (possibly dodecane) application should be studied. Under Phase II flowsheet conditions, solvent losses are reduced to the point where more expensive diluents might be economically attractive if a definite process improvement could be shown to result.

(2) Cold Semiworks Development

- (a) Development of column specifications for a new organic-continuous HA Column is in progress.
- (b) Development of a new bottom-interface HS Column cartridge which is adaptable to the existing HC Column shell for a capacity factor of > 4.0 is required.
- (c) Revised DX and IBS Column specifications for a capacity factor of 4.0 are required. Again, the specification should be limited to only a cartridge change, if possible.
- (d) The 2A Column capacity is unknown under the low acid flowsheet conditions, and capacity studies are necessary.
- (e) IC and 2E Column capacities are limiting and new column specifications are required.
- (f) Interface instrumentation suitable for bottom-interface HA Column application is under development.
- (g) Efforts should continue on the IWW Anion Exchange Prototype.
- (h) Methods for remoting column cartridges should be investigated.

(3) Plant Tests(8)

A number of plant tests can be made which will permit stepwise approach to the Phase II Flowsheet. These tests are outlined below.

- (a) Addition of recovered nitric acid to the top of the IBS Column will eliminate the 2AF-nitric acid addition and determine whether or not improved fission product, UX_1 , and uranium decontamination result.
- (b) Reduction of ferrous sulfamate addition to 2DF will be tested in the near future.
- (c) Capacity tests of the 2D and 2E Columns and the 2EU Concentrator are planned to establish maximum processing rates.
- (d) Recent successful rework of normal IWW solution indicates that routine 2WW backcycle may be possible. Demonstration of routine 2WW backcycle would permit revision of the flowsheet to eliminate one concentrator.

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- (e) Processing of prototypical plutonium ion exchange product through Z Plant without concentration should be tested to determine its effect on Task I capacity.
- (f) The prototype IWW anion exchange unit for plutonium recovery is expected to be completed prior to Phase II installation and will demonstrate plutonium recovery from IWW.
- (g) Efforts should continue to solve the high dissolver tower differential pressures. Antifoam addition may be attempted.
- (h) Alternate solvent washing agents such as the carbonate-permanganate will be tested when radiation instruments can be installed on the organic centrifuges.

IV. Acknowledgement

②

The study flowsheet presented, includes the contributions of many people and organizations. In particular the Purex Operation, Chemical Processing Department, has contributed much in the way of cooperation in plant tests and inspiration toward greater economies. From the Hanford Laboratories Operation, contributions on flowsheet ideas have been donated by the Chemical Research Operation, and the recent "breakthrough" in extraction column design made by the Chemical Development Operation has greatly spurred efforts toward the "Two Cycle Plant." Facilities Engineering Operation, Chemical Processing Department, has contributed considerably to the evaluation of equipment capacities. In addition, all members of the Purex Technology Operation have contributed many of the ideas, and much of their time and experience toward this study. ©

V. References

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2. Letter, "Approach to the Two-Cycle Purex Plant", E. R. Irish to O. F. Hill, January 3, 1957.
3. HW-47712, "Process Specifications for Operational Control - Purex Plant", E. R. Irish, January 7, 1957. ©
4. HW-46742, "Monthly Progress Report, October 1956, Chemical Research and Development," V. R. Cooper, November 16, 1956.
5. HW-33296, "The Path of UX₁ in the Purex Process", W. H. Adams et al, April 15, 1955.

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NOTE: Flowsheet has been revised as presented herein.
7. HW 46028, "Purex Tank Farm Requirements", E. R. Irish, January 28, 1957.
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TABLE I
EQUIPMENT CAPACITY AND APPLICATIONS
MAJOR EQUIPMENT ONLY

A. Columns	Column	Function	Estimated Capacity Factor Existing Equipment	Remarks
	HA-T-E2	Unchanged	≥ 4.0	Design under development; column to be built on site for CF 4.0. Will be organic continuous.
	HS-T-E3	HA Scrub Column	≥ 4.0	New "Zebra" cartridge to be installed in spare HC Column; organic continuous.
	IBX-T-J6	Unchanged	3.1 - 3.9	New column or revised cartridge probably required for CF 4.0; development effort required.
	IBS-T-J4	Unchanged	3.5 - 4.1	Shell size limited by critical mass considerations; cartridge change required.
	IC-T-J7	Unchanged	2.9 - 3.5	New column or revised cartridge required for CF 4.0; development effort required.
	2D-T-K2	Unchanged	> 4.0 - 5.0	Capacity test to be run in near future.
	2E-T-K3	Unchanged	3.5 - 4.0	Revised cartridge or new column may be required.
	2A-T-L1	Unchanged	2.0	No data under revised flowsheet; new or modified column probably required for CF = 4.0.
	2B-T-L2	Unchanged	5.0 - 6.0	Revision desirable on spare column for improved interface control.

TABLE I (Cont.)

Column	Function	Estimated Capacity Factor Existing Equipment	Remarks
XA-T-N2 XC-T-N3	Unchanged	4.0	Development data lacking; prototype experience to demonstrate.
IO-T-G2 20-T-R2	Unchanged	4.0 - 5.0	High temperature operation increases capacity.
IA-T-J2	Function Eliminated	-	J2 canyon position to be occupied by IBSU-HAO Backcycle Pump Tank..
B. Pulse Generators	Existing pulse generators believed adequate for CF 4.0.		
C. Concentrators			
3WB - E-H4	Backcycle Stripper-Concentrator	> 4.0	Formerly HCP Concentrator.
ICU-E-J8	Unchanged	> 4.0	
2EU-E-K4	Unchanged	> 4.0	
Pu Stripper Pu Concentrator	Standby	--	Ion Exchange process replaces.
XCP Concentrator	New		Need and capacity to be determined; present Pu concentrator E-14 can be used.
Acid Concentrator E-F6	Unchanged	> 4.0	Fed directly with waste concentrator condensate.
Waste Concentrator E-F11	Unchanged	> 4.0	
D. Fractionation Equipment			
Acid Absorber-T-F5	Unchanged	4.0	Waste concentration and acid recovery flowsheet designed to permit CF = 4.0.

TABLE I (Cont.)

<u>Column</u>	<u>Function</u>	<u>Estimated Capacity Factor Existing Equipment</u>	<u>Remarks</u>
Vacuum Fractionator T-U6	Unchanged	4.0	Design basis: UO_3 and backup facility recovered acid processed; actual capacity probably in excess of $CF = 4.0$.
E. Dissolvers. TKs-A3, B3, C3	Unchanged	3.7	Slug chutes required for $CF = 4.0$. Tower differential pressure problem must be solved in any case.
F. Feed Make-Up Facilities	Unchanged	3.6	Using maximum centrifugation rate of 10 gpm per centrifuge, paralleling TK-E5 and TK-E6 will make possible $CF = 5.2$.
G. Organic Centrifuges			
G-Q3, G-Q4, G-R3, G-R4	Unchanged	3.5 7.0	One centrifuge Two centrifuges in parallel.
H. Other Vessels			
IAF Tank-TK-J1	Function changed to backcycle acid receiver and pump tank		
IBSU-HAO Tank - TK-J2	IA Column replaced by existing spare 2AF Tank TK-J5; purchase spare TK-J5 with one baffle removed to serve as spare for TK-J5 and TK-J2.		
2AF Tank - TK-J5	Function unchanged; has been tested and found adequate for $CF > 4.0$.		
Acid Accumulator Tank TK-F10	Function changed to 2IW, 2AW and XAW decanter and backcycle concentrator feed tank. Organic phase jetted batchwise to TK-F13 as at present.		
Aqueous Make-Up Vessels	Capacity sufficient for $CF > 4.0$.		
All Other Vessels	Functions unchanged - capacity adequate for $CF > 4.0$.		

TABLE I (Cont.)

Column	Function	Estimated Capacity Factor Existing Equipment	Remarks
I. <u>Samplers</u>			
All type A and type B samplers will provide adequate radiation protection.			
J.	<u>Dissolver Off Gas Backup Facility:</u>	Capacity adequate for CF = 4.0.	
K.	<u>Uranium Lag Storage</u>		
TX-P1, P2, P3, P4	Assuming CF = 4.0 processing, 10 MW/T pile power levels, 90 day cooling, 7 day processing to storage, lag storage required is 330,620 gal; present system=400,000 gal. For CF = 4.0 all tanks to operate in cascade to permit maximum holdup time for U237 decay. (Circulators may be required for agitation.)		

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TABLE II

PRELIMINARY PUREX - UO₂ PLANT RECOVERED ACID BALANCE

Basils: One Ton U Processed from Slug to Powder

Phase II Flowsheet

A. Purex Fresh Acid Users		Pounds HNO ₃ /Ton	
IBX		49.0	
ICX		15.9	
2EX		14.0	
2AS		8.8	
XCX		11.0	
		<u>98.7</u>	

B. Recycle Acid Users		Pounds HNO ₃ /Ton	
Dissolution acid		1936	
Feed make-up		285.4	
HSS		439.0	
IBSF-HNO ₃ add'n.		224.2	
2DIS(1)		352.8	
		<u>3238</u>	

C. Acid Losses		Pounds HNO ₃ /Ton	
IMW		121.5	
Process losses(2)		145.9	
UO ₃ Plant loss		<u>82.3</u>	
		<u>349.7</u>	

D. Recovered Acid(3)		Pounds HNO ₃ /Ton	
AFA		2634	
UO ₃ Plant Acid used as 2DIS		352.8	
		<u>2987.</u>	

E. Supplemental Acid Required(4)		Pounds HNO ₃ /Ton	
Acid losses less fresh acid		251	

F. Total Acid Consumption Fresh + recycle		Pounds HNO ₃ /Ton	
		3337	

G. Per Cent Acid Recovery Purex + UO ₃ combined		%	
		89.5%	

Notes:

- (1) UO₃ Plant acid only.
- (2) Includes acid losses in all condensate and organic streams plus loss in the Backup Facility.
- (3) Includes Acid Absorber acid, Backup Facility acid and all UO₃ recovered acid except that used as 2DIS. Assumes 1000 lbs HNO₃ recovered at UO₃ Plant/ton U processed.
- (4) Can be acid from Redox UNH or fresh 60%. When Redox processing rate 0.25 times Purex rate, Purex must export acid.

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TABLE III

PUREX 241-A WASTE STORAGE OUTLOOK (1)

	241-A Capacity Equivalent Tons U	Cost of Waste Storage, \$/Ton U	Years of 241-A Storage Avail- able (4) at 500 Tons U/Mo. Processing Rate	
<u>CASE A</u> Flowsheet: PFFS III Farm limitations: 12 M Na final concentration; 10 psig hydro- static head limit.	3.0 x 10 ⁴	83	5.1	
<u>CASE B</u> Flowsheet: As in Case A. © Farm limitation: 12 M Na final concentration; no hydrostatic head limitation - fill to 90% capacity.	5.7 x 10 ⁴	44 ©	9.6	
<u>CASE C</u> Flowsheet: PFFS III to Jan. 1, 1959 Phase II Beyond	6.3 x 10 ⁴ (2) 8.3 x 10 ⁴ (3)	27 19	11.6(2) 14.8(3)	
Farm limitation: As in Case A.				
<u>CASE D</u> Flowsheet: As in Case C. Farm limitation: As in Case B.	10.9 x 10 ⁴ (2) 14.4 x 10 ⁴ (3)	14 10	19.2(2) 25.1(3)	

Notes:

- (1) 241-A-103 is 50 per cent full; 241-A-101, 102 contents to be moved to non-boiling storage.
Coating waste disposed to ground or non-boiling storage.
- (2) ICW and 20W stored in 241-A.
- (3) ICW and 20W cribbed or to non-boiling storage tanks.
- (4) As of January 1, 1957.

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TABLE IV

APPROXIMATE PUREX PROCESS ECONOMICS

Note: Only those costs which may be regarded as flowsheet dependent are included. Savings in capital investment are recorded elsewhere in this report.

Basis: Cost per ton uranium processed.

	Purex Plant Flowsheet III (Ref. 3)	Proposed Phase II Flowsheet
A. Waste Storage(1)	\$ 43	\$ 14
B. Plutonium Losses(2)	294	84
C. Uranium Losses(3)	150	75
D. Solvent Losses	62	42
E. Steam and Water(4)	142	114
F. HNO ₃ (5)	19	11
G. Other Process Materials(6)	127	83
	<u>\$ 835</u>	<u>\$ 421</u>
	TOTAL	

Notes:

- (1) 241-A Farm assumed valued at $\$2.5 \times 10^6$, self concentration to 12 M Na concentration, tanks 90% filled. IOW, 20W included; coating waste not included.
- (2) 700 g Pu/ton U metal irradiation level; coating waste losses included.
- (3) Includes coating waste loss.
- (4) Concentrator steam only; other steam users are not flowsheet dependent.
- (5) Fresh acid only.
- (6) Includes NaOH, NaNO₂, Fe(NH₂SO₃)₂, Na₂CO₃, CaCO₃, HSO₃NH₂, H₂SO₄

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FIGURE I

PUREX PHASE II

PROPOSED FLOWSHEET

(SIMPLIFIED)

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1. All flows are relative to SAF flow equals 100 (747 gallons/ton uranium).
2. All temperatures are ambient except as otherwise noted.
3. Composition of dissolver reaction gas has been averaged. Composition of gas will vary with time and mode of dissolver operation.
4. Specific gravities are given for all solutions at 25°C, regardless of operating temperature.
5. Solvent refers to 30 vol. per cent THF in a hydrocarbon diluent of specific gravity equal to 0.796.
6. Plutonium concentrations are based on uranium irradiated to 700 g Pu/ton U.

FIGURE II - 1
PUREX PHASE II
PROPOSED CHEMICAL
FLOWSHEET
FEED PREPARATION
FIRST DECONTAMINATION
AND PARTITION CYCLE

1. All flows are relative to HAF flow equals 100 (747 gallons/ton uranium).
2. All temperatures are ambient except as otherwise noted.
3. Composition of dissolver reaction gas has been averaged. Composition of gas will vary with time and mode of dissolver operation.
4. Specific gravities are given for all solutions at 25°C, regardless of operating temperature.
5. Solvent refers to 30 vol. per cent TBP in a hydrocarbon diluent of specific gravity equal to 0.796.
6. Plutonium concentrations are based on uranium irradiated to 700 g Pu/ton U.
7. Ion exchange resin is Dowex 50W x 8, 50-100 mesh. Flow volumes of resin are for wet settled resin in the hydrogen form.

FIGURE II - 2
PUREX PHASE II
PROPOSED CHEMICAL
FLOWSHEET

FINAL URANIUM CYCLE
FINAL PLUTONIUM CYCLE
PLUTONIUM ION EXCHANGE

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HW-47889

NOTES

1. All flows are relative to RAF flow equals 100 (747 gallons/ton uranium).
2. All temperatures are ambient except as otherwise noted.
3. Composition of dissolver reaction gas has been averaged. Composition of gas will vary with time and mode of dissolver operation.
4. Specific gravities are given for all solutions at 25°C, regardless of operating temperature.
5. Solvent refers to 30 vol. per cent TBP in a hydrocarbon diluent of specific gravity equal to 0.736.
6. Plutonium concentrations are based on uranium irradiated to 700 g Pu/ton U.
7. Vent Jet Condensate flow is fixed at ca. 5.0 gpm.

FIGURE II-3

PUREX PHASE II

PROPOSED CHEMICAL FLOWSHEET

WASTE CONCENTRATION
ACID RECOVERY
BACKCYCLE CONCENTRATION
ORGANIC RECOVERY

END

**DATE
FILMED**

11/02/93