RL-SEP-924 H.C. \$ 2.00; MN .50UC-4, Chemistry
(TID 4500, 46th Ed.)

RELEASED FOR ANNOUNCEMENT
IN NUCLEAR SCIENCE ABSTRACTS

FIRST UNRESTRICTED
DISTRIBUTION MADE

SEP 29 '66

AMMONIUM DIURANATE FILTERABILITY

By

M. H. Curtis

Plutonium Chemistry Laboratory
Research and Engineering Operation
Chemical Processing Department

December, 1965

HANFORD ATOMIC PRODUCTS OPERATION
RICHLAND, WASHINGTON

Work performed under Contract No. AT(34-1)-1350 between
the Atomic Energy Commission and General Electric Company

LEGAL NOTICE

This report was prepared as an account of Government sponsored work. Neither the United States, nor the Commission, nor any person acting on behalf of the Commission:

A. Makes any warranty or representation, expressed or implied, with respect to the accuracy, completeness, or usefulness of the information contained in this report, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately owned rights; or

B. Assumes any liabilities with respect to the use of, or for damages resulting from the use of any information, apparatus, method, or process disclosed in this report.

As used in the above, "person acting on behalf of the Commission" includes any employee or contractor of the Commission, or employee of such contractor, to the extent that such employee or contractor of the Commission, or employee of such contractor prepares, disseminates, or provides access to, any information pursuant to his employment or contract with the Commission, or his employment with such contractor.

This document is
PUBLICLY RELEASABLE

B Steele
Authorizing Official

Date: 9-11-06

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

Printed in USA. Price \$2.00. Available from the
Clearinghouse for Federal Scientific and Technical Information.
National Bureau of Standards
U.S. Department of Commerce
Springfield, Virginia

169
2
336

TABLE OF CONTENTS

I.	INTRODUCTION	1
II.	SUMMARY	1
III.	TITRATIONS	2
IV.	PRECIPITATION RUNS	7
V.	TITRATION RATES	8
VI.	NITRATE SYSTEM, EXPLORATORY	9
VII.	NITRATE SYSTEM, PRECIPITATION	10
VIII.	CHLORIDE SYSTEM	11
IX.	COMPARISON OF SYSTEM FILTRATION RATES	12
X.	WASTE LOSSES	13
XI.	PURITY	14
XII.	RECOMMENDED PROCESS	14
XIII.	FUTURE WORK	17
XIV.	REFERENCES	18
XV.	APPENDICES	
	Appendix A - Drum Filter Calculations	19
	Appendix B - Data For Ammonium Diuranate Precipitations	21

AMMONIUM DIURANATE FILTERABILITY

I. INTRODUCTION

This report provides information on a route for processing U^{233} from nitrate solutions to oxide. Also in this report is information on chloride solutions, since these solutions might be used in processing waste streams in a uranium metal producing scheme.⁽¹⁾ The incentive for this study is that the packaging and shipping of oxide presents smaller problems than with nitrate.

Precipitation of an ammonium salt, commonly designated "Ammonium Diuranate" (ADU), from aqueous uranyl media is a convenient route to uranium oxides.⁽²⁻⁴⁾ It is recognized that uranium may precipitate as a difficult-to-handle hydrous type of slurry. Earlier work has defined the filtration characteristics required for processing slurries of precipitated actinides in existing vacuum drum filtration equipment.^(5, 6) It is necessary to define ammonium diuranate precipitation conditions that will insure these filtration characteristics, and thus assure acceptable vacuum drum filtration.

Experimental work was performed using natural uranium. It was beyond the scope of this work to demonstrate actual U^{233} precipitation; however, the technology developed could be used on any isotopic combinations of uranium. The ammonium hydroxide solutions were prepared from 30% CP grade stock.

II. SUMMARY

Laboratory work has demonstrated that an ammonium diuranate of desired filtration characteristics may be precipitated. A continuous precipitation at 55 °C is used, with a pH of 5.0 ± 1.0 used for control. The feed may be either a uranyl nitrate or chloride solution from 0.1 to 1.25 molar in uranium, and 0.5 to 3.0 normal in acidity. A dilute ammonium hydroxide strike

solution is used to facilitate control of the pH. The precipitator uses vigorous agitation, and is sized to provide a digestion time of 10 to 20 minutes before overflow to the filter. A wash solution of dilute ammonium hydroxide is used to insure that the combined filtrate-wash solution has a pH of greater than 7.0. It insures a nondetectable uranium solubility in the waste solution.

Use of this technology results in a reduction of the level of alkali metal and alkaline earth metal impurities in the uranium by factors of from 10 to 250.

Although continuous precipitation techniques were studied, batch precipitations may also be performed by application of the data obtained.

III. TITRATIONS

Three uranium systems were titrated by adding ammonium hydroxide. The three systems were

- . A nitrate system
- . A uranyl chloride system
- . A chloride system containing both U(IV) and U(VI) ions*.

The titrations were performed in the precipitator so that temperature and agitation would be the same as for the precipitation runs. The metered addition of ammonium hydroxide was at the rate to be used in the precipitation runs.

Titration curves for the three systems are given in Figures 1, 2, and 3. The pH sensing and control problem of staying in the desired pH region is apparent from these curves. A metering accuracy of $\pm 2\%$ is required when using a dilute am-

(*) The solution was made by dissolving U_3O_8 in HCl. The U(IV) to U(VI) ratio was not determined.

monium hydroxide solution; and the accuracy requirement becomes more rigid as the solution concentration increases.

The curves show the variation of pH with the addition of ammonium hydroxide. The initial reaction, up to a pH of about 2.5, is that of neutralizing free acid:

Up to a pH of about 4.0, the uranium is being precipitated by the overall reaction,

Any ammonia hydroxide in excess of that required for the above reactions drives the pH to greater than 6.0 and results in difficult-to-filter precipitates. This is probably due to the reaction,

The shape of the titration curve and these reaction products have been defined by Cordfunke.⁽⁷⁾ Rounding of the otherwise step-shaped curves is a function of the titration rate: a very slow titration would give a nearly theoretical shape to the curves. Therefore, in a continuous system with sufficient residence time, a uniform product should result. It was noted that the pH of the final slurry slowly rises at the end of the run if it is allowed to digest for several minutes.

Figure 1 is typical of titrations in the uranyl nitrate system. The breaks confirm those of Cordfunke,⁽⁷⁾ and subsequent filtration studies confirm that a physical change occurs in the slurry when it is above pH 6.

The uranyl chloride system titration curve is shown in Figure 2. The initial high pH, followed by a dip, is probably due to the high salt concentration of the system; otherwise the curve follows the trend of that for the uranyl nitrate sys-

FIGURE 1. TITRATION CURVE FOR NITRATE SYSTEM

FIGURE 2. TITRATION CURVE FOR URANYL CHLORIDE SYSTEM

FIGURE 3. TITRATION CURVE FOR URANIUM(IV) AND (VI) CHLORIDE

tem in that there is a sharp rise from pH 4 to pH 6.

Figure 3, for the U(IV) and U(VI) chloride system, indicates an early precipitation of $U(OH)_4$, followed by the uranyl precipitation. The effect of this U(IV) precipitation (presumably a hydrous-type hydroxide) was also apparent on the filterability of the slurry.

From all the curves, it is apparent that precipitation is not complete until the pH is greater than 4.0. Thus, to eliminate an excessive load on the polish filter, this value should be the lower control limit for the precipitation.

The sharp rise in the desired pH region indicates control will be facilitated by using dilute ammonium hydroxide and is the basis for recommending the strike solution composition. Thus, if the molarity of the strike solution ammonia is equal to the sum of the feed acidity and 2.3 times the feed uranium molarity, the strike solution volume required will be about equal to the feed solution to maintain the pH at about 5. With both streams having about the same flow, flow regulation should be simplified.

Experience with the experimental runs shows the importance of frequent pH instrument checks to insure that the precipitation is being made in the proper pH region. Startup of a continuous run was found to be made best by addition of ammonium hydroxide to a relatively large heel of uranyl nitrate, and then starting the uranyl nitrate flow when the pH reached the operating region.

IV. PRECIPITATION RUNS

Several exploratory runs were made with the nitrate system to determine the characteristics of the system over a variety of feed composition. Runs were made on feed batches of 100, 300, and 500 ml.

Then precipitations were made from a series of dilutions of a 300 g/liter uranium-3.0M HNO_3 solution. All runs were made with 500 ml feed batches.

Precipitations were made from uranyl chloride systems of various compositions and a mixed U(IV)-U(VI) system. The control pH was 5.0 ± 0.5 , and 500 ml feeds were used for each run.

The precipitation runs were made by metering the feed uranium stream and the strike simultaneously into the precipitator. Digestion times were 10 to 20 min, and vigorous agitation was maintained throughout the runs.

V. FILTRATION RATES

Initial concern was with filtration rates. The parameters used to express filtration rates are given in Appendix A.

Previous work⁽⁶⁾ has established a technique for relating laboratory data to continuous drum filter operation and also has established that plutonium(IV) oxalate had a typical M'' factor (relative weight of product filtered per unit time) value of 5. Thus, if ADU slurries can be precipitated so as to give an $M'' \geq 5.0$, they will be filterable on a continuous drum filter similar to that used for plutonium oxalate filtration. As a specific example of the use of the M'' term, $M'' = 5$ corresponds to the calculated filtration rate of 1 kg of uranium per hour for a pilot plant drum filter 3 in. wide and 12 in. in diameter.

The filtration rate tests were made by taking 100 ml portions of the overflow slurry from the precipitator and testing them in filtration rate equipment as described previously.^(5, 6) The remaining overflow, plus the slurry remaining in the precipitator, were filtered on a filter paper disk in a 600 ml coarse glass frit filter funnel. The filter cake was washed and then calcined.

Calcining of the cakes in air was performed at either 300 °C (for UO_3) or at 500 °C for 2 hr (for U_3O_8). In some instances, calcined cakes were dissolved in HNO_3 for providing feed stock.

VI. NITRATE SYSTEM, EXPLORATORY

Table I shows the summary of results from runs made in exploring the potential of continuous precipitations. The filtration rate tests were made at the end of the run. Complete results of this exploratory run are given in Table B-I, Appendix B.

TABLE I. EXPLORATORY NITRATE SYSTEM RUNS

<u>Feed Solution</u>		<u>Control pH</u>	<u>Relative Filtration Rate</u>
<u>U, g/liter</u>	<u>H⁺, N</u>		<u>M"</u>
75	0.5	4.0	12.6
75	0.5	6.0	6.4
75	0.5	6.0	6.0
75	0.5	10.0	1.25
140	0.5	6.0	10.8
200	0.5	6.0	11.6
235	2.5	7.0	2.4

Run 1 shows the favorable filtration rate but high waste losses resulting if the pH is too low. Run 3 shows the adverse effect of high pH on filtration rates; this run was erroneously made at a pH of 10.0. From these data, at a constant control pH and a constant feed acidity, it appears that higher feed uranium concentrations give a more favorable relative filtration rate.

Cakes resulting from any operation above pH 6.3 (even short transients) result in M" values lower than 3.0, with cakes not only difficult to filter, but having lower density than those made at a lower pH. There is ample evidence that the poor filtration characteristics are not reversible. Hence, a slurry that has been at high pH will continue to be

difficult to handle despite lowering its pH until all of the high pH solids has been removed. Recommended procedure for handling poor filtering slurries is to dissolve them completely, and reprecipitate.

From the exploratory runs, it was concluded that precipitations could be made under conditions giving relative filtration rates (M'') comparable with plutonium oxalate ($M'' > 5$), and thus filterable on the continuous drum filter.

VII. NITRATE SYSTEM, PRECIPITATION

Table II summarizes the results for comparative runs which were made under conditions based on the results of the exploratory runs and the nitrate system titration curves. Two filtration rate determinations were made--one for the first precipitator overflow, and one for the precipitator product at the end of the run. Complete results for these run appear in Table B-II, Appendix B.

TABLE II. CONTINUOUS NITRATE SYSTEM RUNS

Run No.	Feed Solution		Highest pH	Relative Filtration Rate
	<u>U, g/liter</u>	<u>H⁺, N</u>		<u>M''</u>
8	200	2.0	6.2	3.8
			6.3	2.8
9	150	1.5	6.2	2.5
			6.3	2.2
10	100	1.0	6.0	3.4
			6.5	2.2
11	150	1.5	6.0	4.2
			6.0	6.0
12	200	2.0	6.1	3.0
			6.6	3.0
13	100	1.0	6.0	3.3
			5.6	6.7
14	300	3.0	6.3	4.2
			5.8	6.8

The feed acidity was varied in the same ratio as the uranium concentration, representing various dilutions of the same concentration. The data indicate that pH is much more important than dilution, in such a case, for filtering a maximum mass of uranium per unit time.

Despite the objective pH of <6.0 for these runs, transients closely relate to the filtration resistance. From these data, it is seen that pH 6.0 of greater results in relative filtration rates lower than the desired value of $M'' \geq 5.0$.

VIII. CHLORIDE SYSTEM

Table III summarizes the data for representative chloride runs. The complete data are given in Table B-III, Appendix B.

TABLE III. CHLORIDE SYSTEM RUNS

Run No.	Feed Solution		Highest pH	Relative Filtration Rate
	U, g/liter	H ⁺ , N		M''
C-1	100	0.5	6.0	15.2
			5.4	21.2
C-2	200	0.5	5.7	11.0
			5.8	10.3
C-3	300	0.5	7.0	7.2
			5.5	16.6
C-4 (a)	100	0.7	6.0	3.7
			5.5	3.9
C-5	25	0.5	6.5	>3.9
			5.0	>4.4

(a) Has U(IV) present.

Runs C-1, -2, -3 show more of an effect from pH than from feed uranium concentration. The uranium concentration effect may be calculated, since uranium concentration is a factor in deriving M'' (see Appendix A). This pH concentration relationship with relative filtration rate is shown in Table IV.

TABLE IV. CONCENTRATION AND pH EFFECTS
UPON RELATIVE FILTRATION RATE

Run No.	M"	pH	U, g/liter
C-1	21.2	5.4	100
C-3	16.6	5.5	300
C-1	15.2	6.0	100
C-2	11.0	5.7	200
C-2	10.3	5.8	200
C-3	7.2	7.0	300

Run C-4 illustrates the adverse effect of filtering if uranium(IV) ion is present. The feed was prepared from U_3O_8 , resulting in a mixture of uranyl ions and U(IV) ions. On the basis of this run (and the data discussed in the section on titration curves), it is recommended that any feed prepared by dissolving UO_2 , U_3O_8 , or other forms containing U(IV) should be oxidized prior to precipitation.

Run C-5 is included, since it has the feed composition that would result from eluting an anion column with dilute hydrochloric acid.⁽²⁾ In this case, the filtration rate test was limited by the rate measuring technique.

The filtration rate in the test setup was so rapid that the r (filtration resistance) could be expressed only as a less-than figure, resulting with a greater-than M'' value. In such a situation, the solid mass filtered (M) becomes less significant from an engineering standpoint than the filtrate volume (see Appendix A).

IX. COMPARISON OF SYSTEM FILTRATION RATES

There is little difference between nitrate and chloride runs as shown in Table V.

The results of these runs confirm the results for the nitrate runs in respect to the desirability of limiting the maximum pH at 6.0 to give acceptable filterability.

TABLE V. COMPARISON OF
NITRATE AND CHLORIDE FILTRATION RATES

Feed Solution		Run	pH	Relative
U, g/liter	H ⁺ , N			Filtration Rate
				M ⁿ
200	0.5	Nitrate, #6	6.0	11.6
		Chloride, C-2	5.7	11.0
		Chloride, C-2	5.8	10.3

X. WASTE LOSSES

A pH of >9.0 of the combined filtrates has been assumed to prevent excessive waste losses in drawing up the initial flow sheet. A dilute ammonia wash of the filter cake was included for the usual wash reasons, as well as for providing the extra ammonia to raise the pH to 9 in the composited precipitation filtrate and wash. Using a polish filter on this high pH composite would permit disposal of the stream with very low uranium losses. From the titration curves, a wash composition corresponding to 0.25 moles of ammonia per mole of feed uranium is recommended.

Run 1 exhibited uranium color in the precipitation filtrate, and uranium was precipitated when the wash filtrate was added to the precipitation filtrate. Such a condition would result in a heavy load on the polish filter, and was not considered desirable for plant operation. On analysis, the precipitation filtrate was found to be 3.37 g/liter for the pH 4 strike. In all other runs (made at pH 5.0 or higher), the precipitation uranium content was <0.05 g/liter, and all wash-filtrate composites were found to be <<0.05 g/liter. After making the filtration curves, the pH of >7.0 was specified for the composite wastes from the strike and wash.

It should be noted that "carbonate-free" ammonium hydroxide was used in this work to insure that uranium losses would not be raised due to uranium carbonate solubility. CP grade (30%

NH₄OH with 0.002% carbonate content) was used to prepare the strike ammonium hydroxide solutions used.

XI. PURITY

Little cation purification was expected across the precipitation except for alkali and alkaline earth metal elements. Indeed, contamination could occur due to impurities in the water, and reagents used. The spectrochemical results for feed and two product samples for one run are presented in Table VI.

TABLE VI. IMPURITIES IN PRECIPITATION PROCESSES

	<u>Al</u>	<u>B</u>	<u>Ca</u>	<u>Cr</u>	<u>Fe</u>	<u>K</u>	<u>Mg</u>	<u>Na</u>	<u>Ni</u>	<u>Si</u>	<u>Sn</u>	<u>Zn</u>
	Parts per million parts uranium, spectrochemical results											
Feed	2	5	100	50	25	50	500	100	1	1	1	20
Ppt 1	2	20	2	2	25	1	2	10	20	100	10	50
Ppt 2	10	5	10	2	25	1	2	10	5	100	10	100

These results show a cleanup for the alkali metal (K, Na) and alkaline earth metal (Ca, Mg) impurities, Increased contamination for boron and silicon apparently occurred from the borosilicate glassware used, and could be avoided by changes in material of construction. The increases in Al, Ni, Sn, and Zn are not explainable, but may be within expected analytical accuracy.

XII. RECOMMENDED PROCESS

The process technology is summarized by a flow diagram (Figure 4) and a flow sheet (Figure 5). The process specifications are listed in Table VII.

FIGURE 4. ADU PRECIPITATION AND FILTRATION APPARATUS

FIGURE 5. TYPICAL FLOW SHEET ADU PRECIPITATION

TABLE VII. TYPICAL PROCESS SPECIFICATIONS
FOR ADU PRECIPITATION

<u>Variable</u>	<u>Basis</u>
<u>Feed Solution</u>	
Nitrate or chloride system	Tested, this work.
<1.25M uranium	Limits tested in this work.
>0.1M uranium	Excessive solution volumes.
0.5N to 3.0N acid	Limits tested in this work.
Purity better than product	Little purification demonstrated.
<u>Strike Solution</u>	
CP grade	Used in this work.
Low carbonate	To keep waste losses down.
Low impurities	To keep product purity up.
M NH ₄ OH = N (feed acid) + 2.3M (feed U)	Keeps feed and strike volumes about equal for ease of control.
<u>Strike Conditions</u>	
Continuous	Used in this work.
55 ± 5°C	Based on results of prior work.
Vigorous agitation	Used in this work.
10 to 20 min digestion	Used in this work.
Maximum pH 6.0	Filterable below this value.
Minimum pH 4.0	Losses high below this value.
<u>Wash Solution</u>	
Flow, to give dry cake	Used in this work.
Composition - to be pH >7.0 for composited feed and wash	Insure low waste loss.

XIII. FUTURE WORK

Any further development work with ADU precipitation should be based on the variables of the specific application. Although the literature shows a variety of impurities have been tolerated in processing ores, wastes, etc., compositions representing the extremes to be encountered in plant operation

should be tested under plant flow sheet conditions.

If extensive runs are going to be made by this process, it may be desirable to test the British concept of a precipitator for this type of system.⁽⁸⁾ The British "multi-stage feed back precipitation" simplifies the pH sensing and flow control problems.

XIV. REFERENCES

- (1) M. J. Szulinski, U²³³ Processing Flowsheets, RL-SEP-417. May 21, 1965.
- (2) J. Belle, Editor, Uranium Dioxide: Properties And Nuclear Applications, U. S. Atomic Energy Commission, Washington, D.C. (1961).
- (3) W. D. Jamrack, Rare Metal Extraction By Chemical Engineering Techniques, MacMillan, New York (1963), p. 204.
- (4) A. J. Caputo and J. E. Perry, Production, Precision Forming, And Sintering Of Ceramic-Grade UO₂, Y-1301. March 16, 1961.
- (5) R. G. Sowden and G. N. Stockdale, The Characterization Of Precipitates By Filtration Settling Parameters: A Comparison Of Ammonium Diuranate And Uranium(IV) Oxalate, AERE-R-3767. June 24, 1961.
- (6) M. H. Curtis, Laboratory Tests Of Filtration Characteristics, RL-SEP-550. June 9, 1965.
- (7) E.N.P. Cordfunke, "On The Uranates Of Ammonium-I, The Ternary System NH₄-UO₃-H₂O," Inorg. & Nucl. Chem., Vol. 24, pp. 303-7 (1962).
- (8) S. E. Smith, F. Brown, J. S. Broadley, and W.C.L. Kent. Development Of A Large-Scale Manufacturing Process And Plant For Plutonium Plant Reactor Fuel, A/Conf. 28/p/151. May, 1964.

XV. APPENDICES

APPENDIX A

DRUM FILTER CALCULATIONS

APPENDIX A
DRUM FILTER CALCULATIONS (*)

Two expressions may be used to measure drum filter operation. These are

$$(1) \quad V = \left(\frac{2Ap^2xT}{nrC} \right)^{1/2}$$

$$(2) \quad M = A \left(\frac{2pxC}{nrT} \right)^{1/2}$$

where

A = surface area of filter.

x = fraction of drum surface immersed.

M = solid mass per unit time.

T = time of drum revolution.

V = filtrate volume per revolution.

r = filtration resistance.

C = solids concentration.

p = pressure (or vacuum).

n = viscosity.

From the equations, the relative importance of the variables may be seen. However, some assumptions have been made (such as negligible filter media filtration resistance and non-compressible cake) that should be included in the final engineering, but are excluded here.

Slurry properties are expressed in r, C, and n. Viscosity and concentration are subject to some manipulation due to their interdependence, temperature effects, etc. The filtration resistance, r, is the most important variable since it may be varied over a range of powers of 10. (British work showed ammonium diuranate precipitates to give r values from 0.01 to

(*) Adapted from AERE-R-3767. (5)

200 units).

The filtration resistance is determined from the slope of the plot of t/v vs. v , of the data on time (t) versus filtration volume (v) of a batch filtration. Instantaneous values may be determined by the relative t/v^2 .

The primary concern is with relative filterability. Eventually, parameters of the equation should be expressed in compatible units. The term M'' used in this report is expressed in terms set up in RL-SEP-550.

APPENDIX B

DATA FOR AMMONIUM DIURANATE PRECIPITATIONS

TABLE B-I. AMMONIUM DIURANATE PRECIPITATIONS
NITRATE SYSTEM, EXPLORATORY

<u>Run Number</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>7</u>
<u>Feed Solution</u>							
U, g/liter	75	75	75	75	140	200	235
H ⁺ , g/liter	0.5	0.5	0.5	0.5	0.5	0.5	2.5
Flow, ml/min	10	10	10	10	10	8.5	4.2
Total volume, ml	500	500	300	300	100	100	100
<u>Strike Solution</u>							
NH ₄ OH, M	2.1	2.1	2.1	2.1	2.1	2.1	2.1
Flow, ml/min	3.6	5.8	10.0	4.3	9.0	10.0	10.0
<u>Control pH</u>	4.0	6.0	10.0	6.0	6.0	6.0	7.0
<u>Slurry Concentration, U g/liter (C)</u>	55	47.5	37.5	52.4	75	92	70
<u>Filtration Constant (r x 10,000)</u>	0.3	1.0	21	1.25	0.54	0.59	11.1
<u>Relative Filtration Rate (M")</u>	12.6	6.4	1.25	6.0	10.8	11.6	2.4
<u>Strike Filtrate Loss, U g/liter</u>	3.73	<0.05	<0.05				
<u>Strike Cake</u>							
Density, g/cc	-	0.93	-	1.00	1.41	1.62	1.16
Density, g U/cc	-	0.7	-	-	1.08	1.29	0.87

TABLE B-II. CONTINUOUS AMMONIUM DIURANATE PRECIPITATIONS
NITRATE SYSTEM

<u>Run Number</u>	<u>8</u>	<u>9</u>	<u>10</u>	<u>11</u>	<u>12</u>	<u>13</u>	<u>14</u>
<u>Feed Solution</u>							
U, g/liter	200	150	100	150	200	100	300
H ⁺ , g/liter	2.0	1.5	1.0	1.5	2.0	1.0	3.0
Flow, ml/min	10	8	9	9.3	8.7	8.8	8.6
<u>Strike Solution</u>							
NH ₄ OH, M	3.7	2.7	1.5	2.7	3.7	1.8	4.3
Flow, ml/min	10	10	10	10	10	10	10
<u>Slurry Concentration, U g/liter (C)</u>	100	67	47	72	93	47	138
<u>Highest pH</u> ^(a)	6.2	6.2	6.0	6.0	6.1	6.0	6.3
	6.3	6.3	6.5	6.0	6.6	5.6	5.8
<u>Filtration Constant (r x 10,000)</u> ^(a)	6.4	10	4	4	10	4	8
	13.5	12	13	2	10	1	3
<u>Relative Filtration Rate (Mⁿ)</u> ^(a)	3.8	2.5	3.4	4.2	3.0	3.3	4.2
	2.8	2.2	2.2	6.0	3.0	6.7	6.8

(a) Values for filtration test near start of run, and end of run, in that order.

TABLE B-III. AMMONIUM DIURANATE PRECIPITATIONS
CHLORIDE SYSTEMS

<u>Run Number</u>	<u>C-1</u>	<u>C-2</u>	<u>C-3</u>	<u>C-4</u> ^(a)	<u>C-5</u>
<u>Feed Solution</u>					
U, g/liter	100	200	300	100	25
H ⁺ , g/liter	0.5M	0.5M	0.5M	0.7	0.5M
Flow, ml/min	9.4	9.4	9.1	9.2	9.6
<u>Strike Solution</u>					
NH ₄ OH, M	3.02	3.02	4.53	3.00	0.75
Flow, ml/min	4.7	7.3	6.6	5.6	5.5
<u>Slurry Concentration</u> , U g/liter (C)	66.66	112.6	173.8	62.2	15.9
<u>Highest pH</u> ^(b)	6.0	5.7	7.0	6.0	6.5
	5.4	5.8	5.5	5.5	5.0
<u>Filtration Constant</u> (r x 10,000) ^(b)	0.872	0.97	3.57	5.26	<0.25
	0.44	1.11	0.63	4.34	<0.27
<u>Relative Filtration Rate</u> (M") ^(b)	15.2	11.0	7.2	3.7	>3.9
	21.2	10.3	16.6	3.9	>4.4
<u>Filtrate Loss</u> , U g/liter	N.D.	N.D.	0.082	N.D.	0.66
<u>Cake Density</u> , U g/cc	1.43	1.90	2.14	0.54	0.833

(a) Mixed valence state run U(IV) and U(VI).

(b) Values for filtration test near start of run and test at end of run, in that order.

DISTRIBUTIONCopy Number

1	<u>BATTELLE-NORTHWEST</u> Technical Publications
2-333	<u>DIVISION OF TECHNICAL INFORMATION EXTENSION</u>
334-400	<u>ISOCHEM INC.</u> M. H. Curtis (10) H. H. Hopkins, Jr. (10) W. P. Ingalls R. S. Kingsley L. M. Knights L. R. Michels E. L. Moore H. C. Rathvon P. E. Reed A. J. Scott M. J. Szulinski R. E. Tomlinson Isochem File Copy General Electric File Copy Extra (35)
401-404	<u>RICHLAND OPERATIONS OFFICE</u> H. E. Parker R. K. Sharp Technical Information Library