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RECOVERY OF URANIUM FROM VITRO LEACH LIQUORS BY ION EXCHANGE. PART II. CYCLIC COLUMN TESTS COMPARING IRA-400 AND XE-75 RESINS AND CYCLIC TESTING OF A RESIN-IN-PULP SYSTEM

By
Norman N. Schiff
Hans I. Viklund

May 3, 1954

Raw Materials Development Laboratory
Atomic Energy Division
American Cyanamid Company
Winchester, Massachusetts

Technical Information Service, Oak Ridge, Tennessee

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A B S T R A C T

A three-column ion exchange test program on Vitro leach liquors was run to compare the performance of IRA-400 and XE-75 resins with respect to loading, elution, and poisoning characteristics. When a high molybdenum liquor was used as feed to the columns, molybdenum poisoning was shown to occur with both IRA-400 and XE-75 resins; however, this poisoning action was much less rapid and less extensive in the case of XE-75. In this respect the XE-75 was found to be similar to Permutit SE. The use of a six percent caustic regenerant completely restored the ion exchange properties of the poisoned XE-75 resin.

A cyclic resin-in-pulp process for recovery of uranium from Vitro leach liquors and pulps was studied. The Winchester cell was employed for this investigation in conjunction with XE-123 resin -- a plust 20 mesh resin with the exchange characteristics of XE-75. Performance data, including the effects of molybdenum poisoning, indicate that a 12 cell string may be used effectively with seven cells on exhaustion and five on elution.

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I. INTRODUCTION

During the latter part of 1952, samples of then current Vitro leach liquor were received at the Winchester Laboratory for testing in an ion-exchange system. A cyclic three-column ion-exchange test program was completed and the results reported in American Cyanamid Report ACCO-35. For this work a strong base, low cross-linked anion exchange resin, Permutit SE, was used. The results indicated that this liquor could be treated successfully in a column ion exchange system. The presence of molybdenum in these liquors caused a continuing decrease in the uranium capacity of the resin.

At this time the Winchester Laboratory was developing a resin-in-pulp ion exchange system which would treat a desanded leached pulp rather than a clarified leach liquor. The ion exchange resin was to be separated from the desanded pulp by means of a screening device. One such device, a rectangular vertical screen unit known as the Winchester cell, was developed for this purpose, and a test program was established to evaluate this type of cell in a continuous, cyclic resin-in-pulp system.

The volume of leach pulp required to run a continuous resin-in-pulp process could not be made conveniently in the laboratory. Since the ion exchange characteristics of Vitro leach liquor were known, it was decided, with the cooperation of the Vitro Uranium Company, to use samples of Vitro pulp from the slime zone of the second dewatering thickener as a desanded feed for the resin-in-pulp system. These were to be shipped to Winchester at regular intervals.

During the summer of 1953, a small-scale program of column ion exchange testing was set up at the Vitro plant in Salt Lake City. The Winchester Laboratory was kept informed of the progress of the Vitro program by telephoned reports from the New York office of the company. It appeared that at Salt Lake they were unable to duplicate the results reported in ACCO-35, and poisoning of the resin was occurring much more rapidly than would have been predicted on the basis of that report. IRA-400 resin was being used in place of Permutit SE which was no longer available.

An ion exchange testing program was set up at Winchester from July through December 1953, on Vitro pulps and leach liquors. Cyclic column tests were run to check the ion exchange characteristics of the present leach liquor with that liquor produced a year ago. Also, since the resin used previously was no longer available commercially, comparisons were run between IRA-400 and XE-75 resins.

Cyclic bench scale testing of a continuous resin-in-pulp system using the Winchester cell with XE-123 resin was completed.

II. SUMMARY AND CONCLUSIONS

A three-column ion exchange system was run using Vitro leach liquor. Two resins, IRA-400 and XE-75, were compared. With a low molybdenum leach liquor, a uranium to molybdenum weight ratio of 500:1, and IRA-400 resin, a loading of 59 g U_3O_8/L WSR was obtained. There was no evidence of a decrease in loading over a period of 10 resin cycles.

Test work on a high molybdenum leach liquor, with a uranium to molybdenum weight ratio of 6.6:1, showed a drop in uranium loading from 54.3 to 15.6 g U_3O_8/L of wet settled resin (IRA-400) in four cycles. After a caustic regeneration the uranium loading was increased to 45 g U_3O_8/L WSR.

A leach liquor with a uranium to molybdenum ratio of about 14:1 was tested on XE-75 resin. It was found that the initial uranium loading was about 30 g U_3O_8/L WRS; this decreased very gradually with the number of cycles of operation. In one case the loading dropped to 26 g/L in 13 cycles, and in another case there was no drop in 20 cycles. A caustic regeneration will completely restore the uranium capacity of the resin.

When a 0.1 N NH_4Cl + 0.1 N HCl solution was used fresh each cycle for elution, complete elution could be obtained at a nine minute retention time with five column volumes on XE-75 resin and 10 column volumes on IRA-400 resin. There is some evidence of an increase in the volume required with IRA-400 as the resin becomes poisoned.

Precipitate grades of 75 to 80 percent U_3O_8 were obtained from all Vitro liquors with either resin. The precipitation methods, producing products in order of decreasing filterability, are hot ammonia, hot magnesia, cold magnesia, and cold ammonia.

It was shown that substantial amounts of molybdenum could be removed from the Vitro leach liquors prior to ion exchange by means of a charcoal column or sulfide precipitation. The effect of the reduction of the molybdenum content of these liquors on their ion exchange properties is yet to be determined.

A continuous resin-in pulp system was run using the Winchester cell and Rohm & Haas XE-123 resin. Batch loading tests with Vitro liquor indicated that the saturation loading varied from 33 g/L at pH 1.15 to 58 g/L WSR at pH 2.38.

When an artificial solution was run in the resin-in-pulp system, it was found that with seven cells in series, a solution to resin ratio of 5:1 in the cell, and a solution flow rate equivalent to a 10 minute residence time per cell, an average loading of 48.5 g/L was obtained with an average uranium adsorption of 99.4 percent. With Vitro pulp it was found that the residence time had to be increased to 12.5 minutes; an average loading of 30 g U_3O_8/L was obtained.

Continuous elution was carried out in the resin-in-pulp cells. It was found that using five cells in series, a solution to resin ratio of 5:1 in the cell, and a solution flow rate equivalent to 30 minutes residence time per cell, complete elution could be obtained. Seven resin volumes, equivalent to one cell volume, were sent to precipitation.

The resin was given a caustic regeneration after 12 complete cycles on Vitro pulp, despite there being no loss in uranium capacity at this time. The presence of molybdenum on the resin was suspected, and this suspicion was confirmed by the removal of 22 g Mo/L WSR in the regeneration process. It appears that this quantity of molybdenum is not sufficient to interfere with the adsorption of uranium on this particular type of resin.

III. ORIGIN AND DESCRIPTION OF SAMPLES

Samples of leach liquor were sent by the Vitro Uranium Company to the Winchester Laboratory at periodic intervals from July through December, 1953. These samples were taken from the slime zone of the number two thickener, this being the type of feed that would be used in a resin-in-pulp system. The material from the number two thickener was chosen in preference to that from the number one thickener, because it was assumed that more wash water would be used in the dewatering process if ion exchange were to be used for the recovery of uranium. Since dilution of the feed to an ion exchange system is relatively unimportant, a larger amount of wash water may be employed profitably to ensure complete washing of uranium from the leach reside.

For the column work, the pulp samples were filtered and the clear solutions used; for resin-in-pulp studies, the samples were used as received.

The first shipment of Vitro pulp had been produced by leaching straight Temple Mountain ore. The liquor was filtered and used completely for column work. The clear solution contained 1.0 g U_3O_8 and 0.002 g Mo/L, or a uranium to molybdenum weight ratio of 500:1.

Later samples were produced at Vitro from the leaching of mixtures of ores, largely those from Temple Mountain and Marysvale. These pulps ranged between 10 and 20 percent solids and contained 0.5 to 1.2 g U_3O_8/L, averaging about 0.7 g/L. Except for one low molybdenum sample, the uranium to molybdenum weight ratio varied between 6.5 and 15.5 to one, averaging about 10:1. The pH of the pulps, except for the first sample, was from 1.2 to 1.4 and the emf as measured with a platinum-saturated calomel electrode system was from -420 to -470 mv. The first sample, as received, had a pH of 0.8 and an emf of -650 mv. This sample was neutralized with limestone to pH 1.3 and reduced with metallic iron to -450 mv. The other samples were used without adjustment.

IV. TEST WORK DESCRIPTION AND RESULTS

A. Column System

A three-column ion exchange system was employed. The columns were 1/2" I.D. glass tubes containing 50 ml wet settled resin (WSR). This volume of resin produced a bed depth of 15". Two runs were made, not concurrently, one using IRA-400 resin and the other using XE-75 resin.

The system was set up to operate with two columns on series exhaustion and the third column on elution. The exhaustion retention time was established at three minutes, as previous work has shown that with comparable liquors this retention time will put the second column at breakthrough when the first column is nearly at saturation. The volume throughput was adjusted to the grade of liquor so that a constant quantity of uranium was passed through the columns on each adsorption cycle. This quantity of uranium was such that, in the absence of any poisoning, all of the uranium could be adsorbed without saturating the resin with respect to uranium. A more detailed explanation of this volume control procedure may be found in Part I of this series 1/.

The elution retention time was set at nine minutes, and a sufficient volume of eluate was used to insure complete elution; this condition was assumed when the last fraction of eluate assayed less than 0.1 g U_3O_8/L by means of a ferrocyanide spot test. A solution of 0.9 N NH_4Cl + 0.1 N HCl was used for elution. In one or two cases, following standard elution, two column volumes of 1 N HCl were passed through the columns to be certain that no uranium could be further removed. None was found in the HCl effluent, indicating that the standard NH_4Cl + HCl elutriant had completely removed the uranium from the columns. Fresh eluting solution was used in each cycle. The eluting cycle was timed so that it would be completed before the exhaustion cycle ended. For those cycles where the volume throughput on exhaustion was reduced to one liter, the exhaustion time was reduced to less than the elution time. A reduction of the elution retention time from nine minutes to five minutes decreased the total time required for elution, although the total volume of eluate required for complete elution increased.

1. IRA-400 Resin

The three-column ion exchange system was started using the clarified leach liquor from the first shipment of leached pulp received from the Vitro Uranium Company. This pulp was derived from the acid leaching of straight Temple Mountain ore. The liquor assayed 1.00 g U_3O_8 and 0.002 g Mo/L, giving a uranium to molybdenum ratio of 500:1. Thirty loading cycles or 10 complete resin cycles were run. A summary of the data is presented in Table I. The complete data are presented in Appendix Table A-3.

1/ Schiff, N. N., Hollis, E. T., and Lower, G. W., "Recovery of Uranium from Vitro Leach Liquors by Ion Exchange", ACCO-35, March 10, 1954, pp. 22-23.

Table I

Loading Data on IRA-400 Resin

Resin Cycle No.	Resin Loading 1/ g U_3O_8/L WSR	Remarks
1	59.8	
2	59.2	Cycle 1 - 7, U_3O_8/Mo = 500,
3	59.2	U_3O_8 = 1.00 g/L
4	56.8	
5	59.5	
6	59.8	
7	59.1	
8	58.9	Cycle 8 - 10, U_3O_8/Mo = 500,
9	58.0	U_3O_8 = 1.13 g/L
10	58.9	
11	54.3	Cycle 11 - 16, U_3O_8/Mo = 6.6,
12	38.7	U_3O_8 = 1.18 g/L
13	24.4	
14	15.6	
15	45.6	Caustic cleanup of resin
16	45.5	

1/ Loadings are based upon elution data and are averaged for the three loading cycles per resin cycle.

From the resin loading figures, calculated from the elution data, it can be seen that there is no significant decrease in the uranium capacity of the resins during the first 10 resin cycles. The average resin loading for this liquor was 59 g U_3O_8/L WSR. One carboy of this sample of liquor assayed 1.13 g U_3O_8/L. This increase in the uranium content would be enough to account for the differences obtained in the percent adsorption shown in Appendix Table A-3. A 2.5 liter throughput of the lower grade liquor, 1.00 g U_3O_8/L, resulted in 100 percent adsorption. A 2.5 liter throughput of the higher grade liquor, 1.13 g U_3O_8/L, equivalent to 2.8 liters of 1.0 g/L liquor, resulted in 94 percent adsorption.

The feed to the Vitro plant had changed to a mixture of Temple Mountain and Marysvale ores with the result that the leached pulps now contained a relatively high concentration of molybdenum. Starting with the eleventh resin cycle, the feed to the columns was changed to the high molybdenum liquor derived from the above mixture of ores. This liquor assayed 1.18 g U_3O_8 and 0.18 g Mo/L, giving a uranium to molybdenum weight ratio of 5.5:1. Six complete resin cycles were run with this liquor. After four cycles, the resin was given a caustic clean-up treatment consisting of 10 column volumes of a 6 percent NaOH solution flowing at a 10 minute retention time.

The data indicate that there is a very rapid decrease in resin capacity, when the liquor contains molybdenum. In four cycles, the resin loading dropped from 54.3 to 15.6 g U_3O_8/L WSR. After the caustic clean-up treatment the resin capacity was only partially restored (45.5 g/L WSR). This does not mean that a more vigorous treatment would not have provided complete restoration of uranium capacity.

Complete elution of the IRA-400 was obtained by using 10 column volumes of fresh eluate at a flow rate equivalent to a nine minute retention time. As the resin poisoned, the volume of eluate required for complete elution increased to about 12 column volumes.

2. XE-75 Resin

After observing the very rapid decrease in the uranium capacity of IRA-400 resin (71 percent in four cycles), it was decided to compare the results obtained with a low and a high cross-linked anion exchange resin (IRA-400 and XE-75) for this type of solution. A year previous to this work, ion exchange work was done on Vitro liquors with a low-cross-linked anion exchange resin, Permutit SE 1/. With a liquor in which the uranium to molybdenum ratio was about 10:1, a loading of 30 g U_3O_8/L WSR could be obtained. A five percent decrease in loading in eight resin cycles was noted, but a caustic clean-up treatment completely restored the uranium capacity of the resin.

Permutit SE resin is no longer available commercially. Rohm & Haas resin XE-75 is reported to be similar to their IRA-400 resin but with a lower degree of cross-linking. It should be very similar, therefore, to Permutit SE resin.

A three-column ion exchange system was operated with 50 ml of XE-75 resin in each column. Forty complete resin cycles or 120 loading cycles were run. A summary of the data is presented in Table II on page 14. The complete data are presented in Appendix Table A-3.

For the first 11 resin cycles, liquor with a uranium to molybdenum weight ratio of 61:1 was used. For the remaining 29 cycles, the uranium to molybdenum ratio of the liquor averaged 14:1. It is unfortunate that the tests comparing the three different resins could not be run on liquors of the same uranium molybdenum ratio.

From the resin loading figures, calculated from the elution data, it can be seen that a lower initial capacity is obtained with XE-75 resin as compared to IRA-400, but the decrease in capacity of XE-75 resin

1/ Schiff, N. N., Hollis, E. T., and Lower, G. W., "Recovery of Uranium from Vitro Leach Liquors by Ion Exchange", ACCO-35, March 10, 1954.

is very gradual. With the liquors used, the initial loading on the resin was about 30 g U_3O_8/L WSR. After 13 resin cycles, the resin loading was 26 g/L, and the uranium adsorption from the feed had been reduced to 90 percent. A caustic clean-up brought the loading back to 30 g/L, and the uranium adsorption increased to 100 percent. After 20 additional resin cycles a second caustic clean-up was used. At this point, there was no decrease in capacity as indicated by the resin loading, and there was only a one percent decrease in the uranium adsorption. After the clean-up, the uranium adsorption increased from 99 to 100 percent. The indicated resin loading of 35 g/L obtained for the two cycles after clean-up does not check with the amount of uranium fed to the columns, based on the volume throughput and the head assay of the leach liquors. Calculated from the adsorption data, the loading should be 31 g U_3O_8/L WSR.

Table II

Loading Data on XE-75 Resin

Resin Cycle No.	Resin Loading 1/ g U_3O_8/L WSR	Remarks
1	36.2	Cycle 1 - 11 U_3O_8/Mo = 61,
2	31.3	U_3O_8- 0.7 g/L.
3	30.8	
4	25.4	
5	26.2	
6	30.4	
7	31.4	
8	32.8	
9	30.4	
10	28.8	
11	30.2	
12	27.1	Cycle 12 - 16 U_3O_8/Mo = 12.5,
13	26.2	U_3O_8- 0.8 g/L
14	29.9	Caustic cleanup of resin after
15	32.3	Cycle 13.
16	30.6	
17	30.3	Cycle 17 - 36 U_3O_8/Mo = 14.4,
18	29.6	U_3O_8 - 0.6 g/L
19	27.9	
20	28.9	
21	30.6	
22	32.1	
23	32.3	
24	32.1	
25	32.6	
26	29.0	
27	29.5	
28	29.9	
29	30.2	
30	28.8	
31	30.7	
32	31.6	
33	29.8	
34	35.2	Caustic cleanup of resin after
35	35.5	Cycle 33.
36	31.3	
37	27.7	Cycle 37 - 40 U_3O_8/Mo = 15.3,
38	27.2	U_3O_8 - 0.6 g/L
39	31.8	
40	32.8	

1/ Loadings are based upon elution data and are averaged for the three loading cycles per resin cycle.

Complete elution of XE-75 resin was obtained by using five column volumes of fresh eluate at a flow rate equivalent to a nine minute retention time. There is no evidence of any increase in the volume of eluate required for complete elution as the resin poisons.

An examination of the data in Tables I and II indicates that XE-75 suffers from molybdenum poisoning to a lesser extent that does IRA-400; however, since the liquors differed in molybdenum concentration, a direct comparison of the poisoning properties of IRA-400 and XE-75 resins cannot be made on the basis of the tests described above. Additional information compiled by D. C. McLean and R. H. Shepherdson of the Winchester Laboratory, working in Salt Lake City under a cooperative arrangement with the Bureau of Mines, may be cited here. Using liquors which were essentially identical in uranium and molybdenum content, they have demonstrated the rapid deterioration of IRA-400 capacity as contrasted to the slower drop in uranium capacity of XE-75 with molybdenum poisoning. Their data are presented in Table III.

Table III

Comparison Effect of Mo Poisoning on Saturation Loadings of IRA-400 and XE-75 Resins

Resin Cycle No.	Resin Loading - g U_3O_8/L WSR					
	IRA-400	XE-75				
	hi and lo Mo Liquors 1/	hi Mo Liquor 2/		lo Mo Liquor 3/		
1	62	29.7		27.5		
2	63	27.1		27.3		
3	66	25.1		27.9		
4	68	23.5		24.7		
5	67	22.9		29.5		
6	60	21.8		25.6		
7	52 (Mo introduced)	20.4		20.4		
8	30	19.6		21.8		
9		20 2		21.1		
10		18.8		25.2		
11		16.8 4/		22.6		
12	23.6		23.4 5/	23.8		
13	20.4		24.5	25.5		
14				27.7		

Note: All liquors were very similar except for differences in Mo concentration; they contained 1.1 g U_3O_8/L; all had a pH of 1.5; and the emf of the liquors was -390 to -420 mv.

1/ A low molybdenum liquor (0.06 g Mo/L) was used for cycles 1-6; a high molybdenum liquor (0.2 g Mo/L) was used for cycles 7 and 8.

2/ High molybdenum liquor (0.2 g Mo/L) was used throughout the run.

3/ High molybdenum liquor was stripped by adsorption on a charcoal column to leave a residual Mo concentration of 0.04 g/L.

4/ XE-75 resin given a caustic regeneration after cycle 11.

5/ XE-75 loading after regeneration run as a duplicate single column test.

From the above data, it may be seen that on the same liquor IRA-400 suffers from poisoning much more rapidly than does XE-75. The last column in Table III is presented to show a property of this batch of XE-75 resin which must be mentioned to put the poisoning phenomenon in its proper light. Both in the presence and absence of poisoning agent, some lots of strong-base anion exchange resins undergo an unexplained initial drop in capacity in the first few cycles. The loadings for regenerated poisoned resin represent, essentially, complete restoration of the resin to what may be considered its normal uranium capacity.

On the basis of the previous tests with Vitro liquor on Permutit SE resin, the poisoning characteristics of SE and XE-75 appear to be very similar. Except for a higher initial uranium capacity for the SE resin, the loading and elution behavior of these two low-cross-linked resins also appears to be comparable. Additional work performed by McLean and Shepherdson confirms this.

3. Precipitation Tests

Precipitation of the column eluate was not done on a regular basis, since recycling of the barren eluate was not required in these tests. A composite of eluates from IRA-400 columns was made for comparison tests using ammonia and magnesia for precipitation. Previous data indicated that there is no difference between eluates obtained from IRA-400 and XE-75 (or Permutit SE) resins. Precipitates made at irregular intervals during the entire column test varied between 75 and 80 percent U_3O_8.

Four 1.6 liter aliquots of the composite eluate were taken. MgO and NH_3 were compared using hot (90°C.) and cold (25°C.) precipitation. The data are presented in Table IV.

Table IV

Comparison of MgO and NH_3 Precipitation

	MgO		NH_3	
Temperature	90°C.	25°C.	90°C.	25°C.
Amount used, g	6.3	7.2 4/	5.2	4.9
Settled volume 15 min., ml 1/	50	140	50	1400
Settled volume 1 hour, ml	50	125	50	540
Filtration time, min. 2/	5.2	9.3	4.3	100
Ppt. grade, % U_3O_8 3/	74.0	82.0	75.3	76.6

1/ 1.75 liters of pulp used for all tests (1000 ml = 7-5/8")
2/ Entire volume of pulp filtered on Buchner filters of same size, time measured until top of cake dried. Filtration done cold.
3/ Precipitate assayed on dried basis. Loss on ignition at 750°C. about 20 %.
4/ Excess MgO used, pH 7.8 instead of 7.0.

The filtration characteristics of a cold ammonia precipitation are very bad, and in practically all cases this method of precipitation would not be recommended. In order of decreasing filterability, hot ammonia, hot magnesia, and cold magnesia would be preferred. The differences between these latter three precipitants are small, and an economic evaluation would have to be made for each specific installation.

4. Removal of Molybdenum from Vitro Leach Liquors

Since it is evident that molybdenum interfers with the adsorption of uranium by ion exchange resins, some preliminary tests were run to attempt the removal of molybdenum from solution prior to ion exchange. Two methods were tried: adsorption on a charcoal column and sulfide precipitation.

The leach liquor was run through a 1/2" diameter column containing 50 ml of Permutit CarboDur, an activated charcoal, at an exhaustion retention time of three minutes. The liquor assayed 0.55 g U_3O_8 and 0.055 g Mo/L. A total volume of 18.75 liters or 375 column volumes was put through the column. The molybdenum assay of the effluent ranged from 0.007 to 0.022 g/L from beginning to end of the run. The calculated average molybdenum assay for the composite effluent was 0.0145 g/L, corresponding to a total molybdenum extraction from the solution of 73.6 percent.

The molybdenum may be removed readily from the CarboDur with a six percent NaOH solution followed by an acid wash. The molybdenum precipitates in the caustic effluent and in the column. The acid wash will remove the molybdenum precipitated in the column.

This one cycle of molybdenum adsorption on and elution from the CarboDur was followed by a second cycle to see if the CarboDur would continue to pick up molybdenum. Eighteen liters or 260 column volumes of a second batch of leach liquor was used for the second cycle. This liquor assayed 0.64 g U_3O_8 and 0.027 g Mo/L. The composite effluent assayed 0.008 g Mo/L, giving a total molybdenum extraction from the solution of 74.1 percent. The molybdenum was again eluted with a six percent NaOH solution followed by an acid wash.

From these two cycles it appears that a CarboDur column of the same size as the XE-75 uranium adsorption column will remove 75 percent of the molybdenum from a volume of leach liquor sufficient for seven uranium loading cycles.

Sulfide precipitation tests were run on a batch of liquor that assayed 1.18 g U_3O_8 and 0.18 g Mo/L. The liquor was reduced with metallic iron to convert most of the ferric iron to ferrous. The reduced liquor had an emf of -400 mv. Sixteen 100 ml aliquotes were used for tests in which the pH and Na_2S concentration were varied. The data are presented in Table V.

Table V

Sulfide Precipitation of Molybdenum

Test No.	pH 1/	Na_2S g/L	Filtration Assay g/L 2/		% Molybdenum Precipitated
			U_3O_8	Mo	
1	0.50	2	1.10	0.12	33
2	0.50	4	1.18	0.06	67
3	0.50	6	1.02	0.05	72
4	0.50	8	1.07	0.04	78
5	0.80	2	1.19	0.14	22
6	0.80	4	1.19	0.09	50
7	0.80	6	1.27	0.04	78
8	0.80	8	1.20	0.04	78
9	1.10	2	1.18	0.16	11
10	1.10	4	1.24	0.08	56
11	1.10	6	1.09	0.03	83
12	1.10	8	1.12	0.03	83
13	1.50	2	1.13	0.17	6
14	1.50	4	1.11	0.09	50
15	1.50	6	1.11	0.05	72
16	1.50	8	1.27	0.01	94

Note: Head assay before reduction = 1.18 g U_3O_8/L., 0.18 g Mo/L, 1.3 g Fe^{++}/L, 3.0 g Fe^{+++}/L, 0.66 g V_2O_5/L, 0.70 g P_2O_5/L, pH = 1.3

1/ Initial pH adjustment was made with H_2SO_4 or NH_3 as required; H_2SO_4 was added to the solution during precipitation to maintain constant pH.

2/ Solutions allowed to stand for 30 minutes at 25°C. after addition Na_2S.

The sulfide precipitates were washed with an H_2S solution and analyzed. While the results for the determination of uranium are somewhat erratic, less than one percent of the uranium is carried down with the molybdenum.

After reduction of the liquor with iron, the addition of 4 g Na_2S/L of leach liquor precipitates about 50 percent of the molybdenum and 6 g Na_2S/L increases this to about 75 percent. An increase in pH at these levels of sulfide concentration helps to make the precipitation more complete.

Further work should be done to determine the effect of partial molybdenum removal on the ion exchange properties of these modified liquors. Both sulfide precipitation and the use of the charcoal column should be studied in this regard.

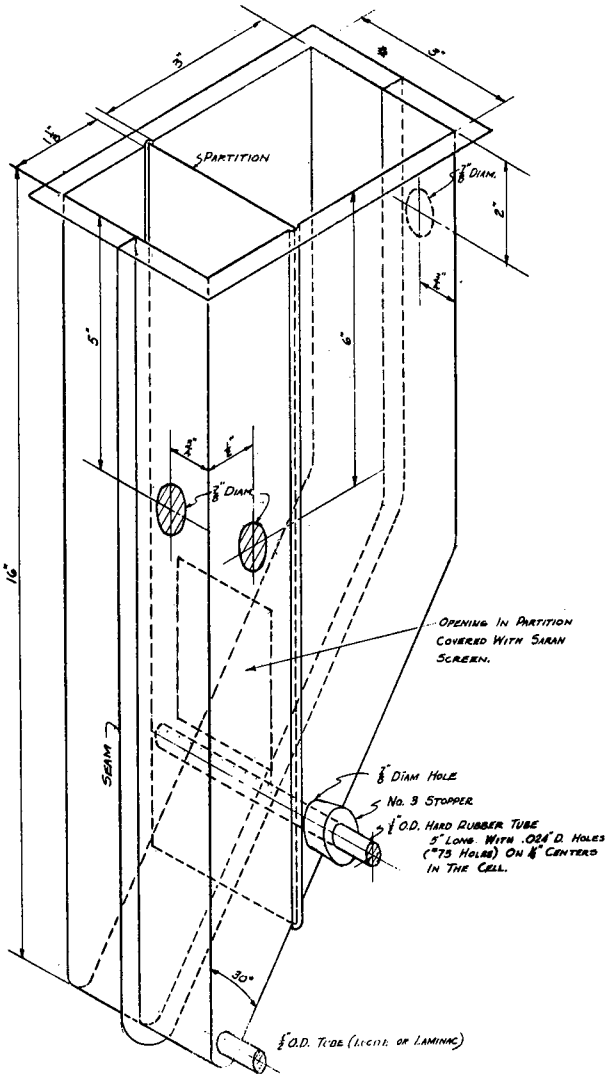
B. Resin-in-Pulp System

A vertical screen unit, known as the Winchester cell, was devised and built at the Winchester Laboratory as a device for a resin-in-pulp system. The cell, a rectangular tank with a 60° sloping bottom, was made of 3/8" lucite sheet. It is divided into two sections by a removable vertical partition. A section of the partition had been cut out and replaced with screening material. Figure 1, on the following page, is a detailed drawing of the one liter laboratory unit employed in the test work.

As currently practiced, the resin-in-pulp process required a big-bead form of resin. Rohm & Haas XE-123 resin has been produced for this purpose. This is a large particle form of the low cross-linked XE-75 resin, and it is supplied in batches which vary from 100 percent plus 35 mesh to 100 percent plus 20 mesh. The resin is contained in the 3" x 3" compartment of the unit. The screening must be about two mesh sizes smaller than the finest resin particle to prevent blinding of the screen. A Saran screen equivalent to 48 mesh was used in these tests, and the pulp-feed to the cells was maintained at minus 65 mesh to avoid blinding of the screen by particles of pulp.

The pulp is fed into the resin compartment of the cell and intimately mixed with the resin. The pulp is separated from the resin as the former flows through the screen into the overflow compartment and out of the cell through the overflow tube. An air distributor placed at the base of the screen prevents the flow of pulp from packing resin against the screen, which would block further flow of pulp. The air distributor is drilled with 0.024" diameter holes (#75 drill) on 1/4" centers. Jets of air are directed against the bottom of the screen. The rising stream of air bubbles sweeep the screen clear and also provide for mixing of the pulp and resin.

It was noted, after several weeks of operation, that considerable wear was occurring at the base of the plastic screen where the jets of air hit. To overcome this problem, strips of fiberglass impregnated with laminac resin were cemented across the bottom of the screen.



1 LITER WINCHESTER CELL

NO SCALE

Figure 1. Winchester Cell

A resin-in-pulp system was set up with 12 of the one liter Winchester cells in series. The full cell volume was 1.2 liters, of which 0.81 liters was occupied by the resin compartment. Each cell contained 145 ml WSR or a pulp to resin ratio of approximately 5:1 in the resin compartment. There was in each cell an eight square inch (4" x 2") section of Saran screen. The system was so arranged that either pulp or eluting solution could be fed into any cell. The overflow tube from each cell was arranged to feed the next cell in series or to collect the composite barren pulp or high grade eluate. The last cell in the series was connected by a pump to the first cell to complete the circuit. A diagram of the resin-in-pulp circuit is presented in Figure 2.

The resin-in-pulp was operated with a fixed number of cells in series for both exhaustion and elution. The ratio of pulp or solution to resin was maintained at the same value in all tests. The residence time in each cell (flow rate) and the volume throughput were varied during exhaustion runs, so that when the overflow from the last cell in series contained an arbitrary concentration of uranium (break-through or cut-off value), the first cell in series was loaded to saturation with uranium. Under the conditions of a particular test, saturation is considered to be achieved when the overflow and the feed to the cell are equal in uranium concentration.

Series elution was similarly controlled by residence time and volume throughput, and the elution terminated when the eluate in the first cell - most completely eluted - contained less than 0.1 g U_3O_8/L as determined by a ferrocyanide spot test. The number of cells in series and the residence time on elution had to be chosen to permit a total elapsed time for elution equal to or less than the time for exhaustion.

At the end of the exhaustion cycle, the first cell in series was drained. The pulp from this cell, since it had the same concentration as the feed, was returned to the head tank. This cell was then twice washed, by filling with water and agitating a few minutes, and drained to remove the slimes and sand from the resin. It then became the last cell in series on the next elution cycle. A freshly eluted cell was added as the last cell on the next exhaustion cycle. At the start of the exhaustion cycle, the first cell volume of pulp fed to the system overflowed into the last cell, which was empty. This is the same volume of pulp returned to the head tank at the end of the previous exhaustion cycle. This first cell volume of pulp was followed by a volume of pulp containing sufficient uranium to saturate one cell volume of resin. This volume of pulp overflowed the last cell, and it was collected as barren effluent.

Normally, at the end of the elution cycle, the first cell in series was drained. The eluate, containing less than 0.1 g U_3O_8/L, was added to the recycle eluate tank. The cell was then washed and drained to remove eluate from the resin, so that none of the chloride ion would find its way into the exhaustion circuit. At the start of the elution cycle, one-cell volume of recycled eluate was fed into the system and overflowed into the last cell, which was empty. This was followed by sufficient fresh or made-up eluate to completely elute the resin in the first cell. The eluate that overflowed the last cell is the high grade eluate that was sent to precipitation.

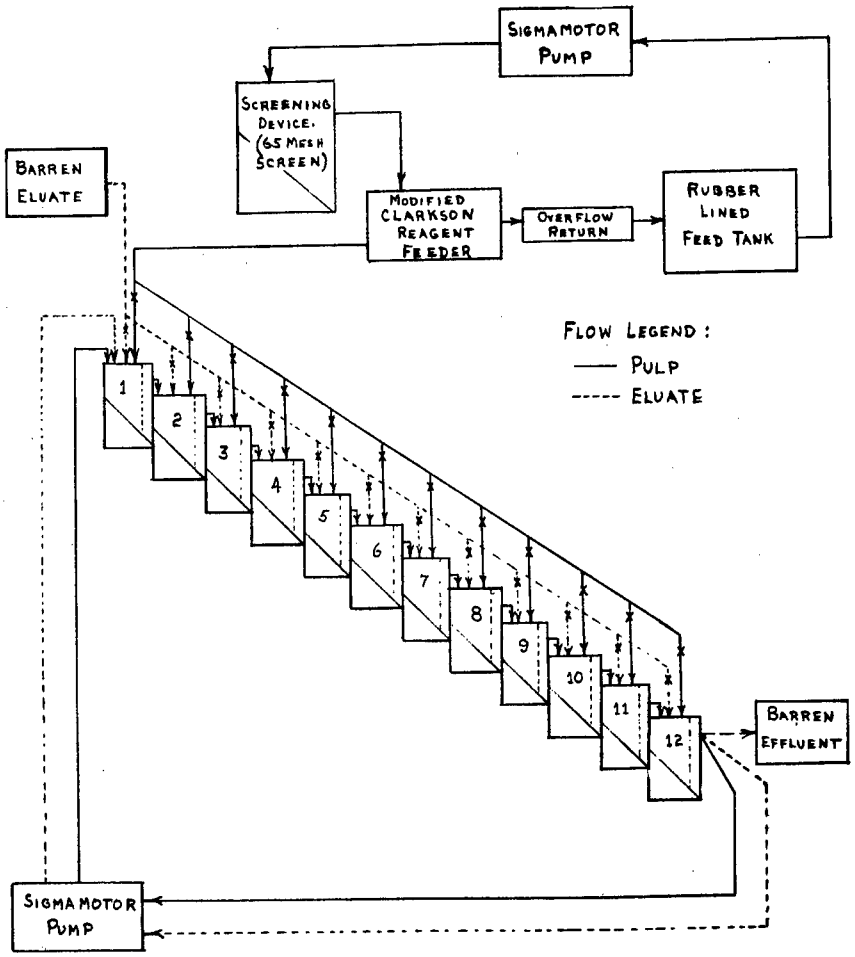


Figure 2. Resin-in-PULP Circuit .

The resin used for this test was Rohm & Haas XE-123, Lot No. 8772. The size distribution of the beads in this sample is shown in Table VI.

Table VI

Size Distribution of XE-123 Resin Lot No. 8772

Size	Wt. %
+14	0.2
-14 + 16	1.5
-16 + 20	12.9
-20 + 28	75.9
-28 + 35	9.0
-35	0.5

Vitro pulp, obtained from the slime zone of the number two thickener, was used as feed for the resin-in-pulp system. A screen analysis of a sample of this pulp is presented in Table VII.

Table VII

Size Distribution of Vitro Pulp

Size	Wt. %
+65	1
-65 + 100	2
-100 +150	4
-150 +200	6
-200	87

The plus 65 mesh fraction consisted mostly of wood chips and particles of carbonaceous matter. To prevent plugging of the screens in the resin-in-pulp system, an extra cell was set up with a 65 mesh screen. This cell was used as a pre-screening device. The feed to the cells, therefore, was all minus 65 mesh. The pre-screening device was cleaned out at periodic intervals.

1. Batch Saturation Tests

Batch saturation tests were run to determine the saturation loading of this resin at various pH values. Leach liquor filtrate from a sample of Vitro pulp was used. The liquor was adjusted to the indicated pH with limestone, and the gypsum precipitate was removed by filtration. Tests were run at five pH values.

For each test a 10 ml sample of resin was contacted successively with four batches of liquor for two hours per contact. Three liters of liquor were used per contact or a total volume of 12 liters per test. The results of these tests are presented in Table VIII.

Table VIII

Effect of pH on Resin Loading

pH	1.15	1.42	1.80	2.20	2.38
Resin Loading, g/L	33.4	39.2	36.3	50.4	58.0
Resin, Assay, % U_3O_8	8.26	9.85	9.00	12.45	14.07
Mo	5.61	2.65	2.05	1.70	1.32
P_2O_5	0.46	0.31	0.30	0.34	0.32
Fe	0.79	0.92	1.46	1.13	2.07
V_2O_5	0.2	0.2	0.2	0.2	0.2

Note: Head assay of solution = 0.77 g U_3O_8/L, 0.096 g Mo/L, 0.35 g P_2O_5/L, 0.53 g V_2O_5/L, 1.27 g Fe^{++}/L, 1.50 g Fe^{+++}/L, pH 1.15. emf -420 mv.

The phosphate and vanadium loadings appear to be independent of pH within the limits tested. Loadings for uranium and iron increase with pH, while molybdenum loading decreases as the pH rises. It appears that the optimum ion exchange properties of this liquor are obtained at the higher levels of the pH range studied. Unfortunately, because of the tendency for precipitation of heavy metal phosphates, arsenates and vanadates, with possible precipitation of uranium at the higher pH values, the practical limit for the ion exchange process is about pH 1.8.

2. Continuous Exhaustion, Resin-in-pulp System

A 12 cell resin-in-pulp system was set up as described above. The total volume of the cell was 1.2 liters and 0.81 liters for the resin compartment alone. The number of cells for exhaustion was fixed at seven. Each cell contained 145 ml WSR, giving a pulp to resin ratio of approximately 5:1 in the resin compartment of the cell. The system was started on an artificial leach liquor and then switched to Vitro pulp. A summary of the data is presented in Table IX, and the complete data are presented in Appendix Table A-1.

Table IX

Summary of RIP Exhaustion Data

Cycle Nos.	Head Assay, g/L of contained liquor	Average % Adsorption	Average Calc.[1] Loading g U_3O_8/L WSR
1- 37 [2]	0.94 U_3O_8, 35 $SO_4^=$, pH = 1.5, Artificial solution	99.4	48.5
38- 89	0.77 U_3O_8, 0.10 Mo pH = 1.15, emf = -420 mv. 20 % solids, Vitro pulp	99.5	30.8
90-113	0.49 U_3O_8, 0.04 Mo, pH = 1.20 emf = -470 mv 10 % solids, Vitro pulp	98.7	30.7
114-125	0.76 U_3O_8, 0.06 Mo, pH = 1.25, emf = -460 mv. 35 % solids, Vitro pulp	98.5	28.3
126-188	0.60 U_3O_8 pH = 1.35, emf = -430 mv. 19 % solids, Vitro pulp	96.8	28.5 (30.2) [3]
189-261	0.58 U_3O_8, 0.04 Mo, pH = 1.40, emf = -430 mv. 20 % solids, Vitro pulp	98.1	26.6
262-308	0.58 U_3O_8, 0.04 Mo, pH = 1.35, emf = -420 mv. 15 % solids, Vitro pulp	96.5	25.5 (29.6) [3]

Note: Solution throughput and resin loading were based on the original volume of resin. At the end of the run there was a 13.8 % decrease in resin volume.

1/ Loading based on eluate assays.
2/ Artificial solution cycle 1-37. Cycle 38-308 Vitro pulp.
3/ Resin loading corrected for resin volume change.

The artificial leach liquor was run for the first three resin cycles (37 loading cycles). An average loading of 48.5 g U_3O_8/L. WSR was obtained. The leach liquor flow rate was equivalent to a 10 minute residence time in the resin compartment of each cell or a total contact time of 70 minutes. With the use of a 10 minute residence time, it was found that the first cell in series was essentially at saturation when the last cell was not yet at breakthrough. In the case of the artificial liquor, with seven cells on exhaustion and a solution to resin ratio of 5:1, a flow rate equivalent to somewhat less than a 10 minute residence time could be used to produce a saturated resin and still obtain complete uranium adsorption.

The loading data (except for figures in parentheses) presented in Table IX are calculated on the basis of the original resin volume. It is known that the resin volume was constantly decreasing. At the end of cycle number 188 the resin volume was measured as 137 ml, and, therefore, the resin loading actually would be 30.2 g/L. At the end of the test, the resin volume was 125 ml, and the loading, calculated on the new resin volume, would be 29.6 g/L. Thus a loading of about 30 g U_3O_8/L. WSR was obtained for the entire Vitro resin-in-pulp run.

3. Continuous Elution, Resin-in-Pulp System

With the use of an elution flow rate equivalent to a 30 minute residence time per cell, it was found that the time required for the completion of the elution cycle was less than that required for the exhaustion cycle. Therefore, nothing could be gained by decreasing the total time for elution through speeding up the elution flow rate; such a procedure would have resulted only in increasing the total volume of eluate required for complete elution. It was shown in previous batch elution tests [1] that equilibrium was established in about 30 to 45 minutes. Therefore, there would be little or no possibility of decreasing the volume of eluate required for complete elution by running the elution at a residence time of greater than 30 minutes. The residence time for elution was fixed therefore at 30 minutes, and the only variables tested for the elution system were the number of cells in series and the method of elution.

A solution of ammonium chloride + hydrochloric acid was used for elution. The pregnant eluate was treated with ammonia to precipitate the uranium and filtered. The barren filtrate was acidified to pH 1.1 with concentrated hydrochloric acid, and any chloride deficiency below 1.0 N was remedied by addition of ammonium chloride. In no case did the addition of HCl to pH 1.1 raise the chloride concentration above 1.1 N.

1/ Abrams, C.S., and Kaufman, D., "Preliminary Studies of the Adsorption of Uranium in a Resin-In-Pulp System", ACCO-26, July 27, 1953.

This type of elutriant is not the most economical solution that might be used, but its use is a laboratory convenience. With ammonium chloride+ hydrochloric acid, no important savings in elution or precipitation reagent costs result from a reduction in the volume of eluate sent to precipitation, once that volume is such that the total amount of chloride required to make the barren eluate 1 N in chloride ion is provided by the hydrochloric acid added to reduce the pH to 1.1. If a sodium chloride + sulfuric acid eluting solution were to be used with ammoniaprecipitation, a decrease in elution volume would lead to a reduction in elution costs. For this reason, an investigation was made of the factors affecting the volume of solution required for complete elution. The complete elution data are presented in Appendix Tables A-1 and A-2.

When the normal elution procedure of feeding all solution into the first cell and overflowing from the last cell was tried, it was found that, with four cells in series, 1.5 liters of eluate were required for complete elution. This is equivalent to about 10.5 resin volumes. With five cells in series, the volume of eluate required was about 1.0 liters or seven resin volumes. If a further reduction in volume were desired, more cells would have to be added to the elution string. It should be noted that no increase in the volume of eluate needed for complete elution was indicated as the number of cycles progressed.

Several modifications of the elution procedure were investigated. It should be recalled that at the start of the elution cycle, the first cell in series is most nearly eluted, while the fifth cell is empty of solution and has just been added to the string after coming off of the exhaustion cycle. It was thought that, by draining high grade eluate from the last cell rather than by diluting it with lower grade eluate and overflowing from the cell, a smaller volume of fresh eluate would be required to produce a barren resin. To test this theory, at the beginning of the elution cycle, a pre-determined volume- 0.7, 0.8, or 1.0 liters - was overflowed at the standard rate to empty fifth cell and then drained completely while the air agitation continued in all five cells. When the last cell was again empty, and the drained liquor sent to precipitation, the flow of eluate was resumed for one full cell volume. At the end of elution the first cell was drained, the liquor being held to be used as the first cell volume of eluate on the next elution cycle, as it contained some uranium. Since the volume throughput is one cell volume plus the volume sent to precipitation, only the latter must be replaced as make-up with uranium free eluate. By the standard elution procedure, complete elution of the first cell was achieved in 2.2 liters throughput - 1.0 liter sent to precipitation. Sending this same volume to precipitation in the modified procedure permits a slightly lower uranium content in the eluate drained from the first cell at the end of elution. This greater efficiency at the same volume throughput is undoubtedly achieved by the batch elution operation which proceeds during the time that the one liter of eluate is being drained from cell five.

It was found that with this modified technique, 0.8 liters of solution or 5.5 resin volumes produced the same degree of completeness of elution as did the standard procedure with seven resin volumes of eluate. The use of 0.7 liters sent to precipitation would not produce a uranium-free resin (eluate containing less than 0.1 g U_3O_8/L) in the first cell.

Two other methods, in both of which pregnant eluate overflow from cell five was reserved for a preliminary batch elution of cell five on the next elution cycle, were attempted, but the results were not encouraging. In addition, certain features of the last modifications would have made these schemes unattractive for plant usage, even if further work were to indicate that lower reagent costs might be obtained. A summary of the data obtained by these elution systems is presented in Table X.

Table X

Summary of Elution Data

Procedure	Vol. of Eluate Sent to Ppt, L.	Assay of First Cell Eluate, g U_3O_8/L
1	1.0	0.09
2	1.0	0.05
2	0.8	0.09
2	0.7	0.3
3	0.5	0.6
4	0.5	0.3

NOTE: Five cells are used in series for all tests.

4. Reagent Consumption and Precipitation Grade

The high grade eluate was precipitated with anhydrous ammonia at a temperature of about 75°C. The barren eluate was made up to the original volume with water, acidified to pH 1.1 with concentrated hydrochloric acid, and brought to 1.0 N chloride ion with ammonium chloride. In most cases the addition of ammonium chloride was unnecessary. The complete data are presented in Appendix Table B-2.

5. Caustic Regeneration and Resin Loss

The resin was given a caustic regeneration starting with loading cycle 181. Each cell, after completion of elution, was given three 1/2 hour contacts with 500 ml of six percent NaOH, followed by 500 ml of 1 N HCl, also for 1/2 hour. A water wash was given the resin before and after the acid contact. An average of 3.2 g Mo was removed from each cell or a recovery of 22 g Mo/L WSR. The caustic regeneration was performed despite there being no evidence of loss in resin capacity at this time - 15 complete resin cycles.

After the regeneration, the resin volume was measured. The average resin volume at this time was 137 ml WSR per cell. This is a loss of 5.5 percent in three months of 22 percent per year. At the end of the run the resin volume was measured again and found to average 125 ml WSR per cell. This corresponds to a loss of 14 percent or an annual loss of 42 percent.

The resin loss is calculated on a time basis, because it is believed that this loss is all due to attrition. The agitation in the cell, the cause of the attrition, is continued 24 hours a day, seven days a week. A further discussion of the attrition problem with the Winchester cell may be found in a separate report[1/].

For the latter part of the run the pulp changed to one containing more sands. It is believed that the more sandy nature of the pulp resulted in the increase in resin wear. Laboratory tests of the larger scale models of the Winchester cell indicate that the amount of air required for agitation and sweeping of the screen is proportionately much less, and, therefore, the resin loss is appreciably less in these larger units.

Table A-1

Complete Data of Resin-in-Pulp Tests
Part 1, Adsorption

Cycle No.	Cells on Ads	Preg Assay	Assay[1] 1	2	3	4	5	6	7	Comp Eff	Barren Volume	Wash Vol	Wash Assay	Time Ads	% Ads	Load
1	1-7	0.94	.72	.44	.22	.059	.016	.0043	.0012	.0008	9	1.19	.044	10	99.9	
2	2-8	"	.77	.56	.20	.051	.021	.003	.0009	.0006	"	1.01	.030	"	99.9	
3	3-9	"	.94	.57	.34	.055	.023	.006	.002	.0009	"	1.04	.016	"	99.9	
4	4-10	"	.90	.67	.36	.11	.032	.007	.002	.001	"	1.07	.16	"	99.9	
5	5-11	"	.83	.61	.42	.16	.037	.008	.002	.001	"	1.09	.14	"	99.9	
6	6-12	"	.77	.39	.21	.046	.017	.004	.003	.002	"	1.07	.14	"	99.8	56.1
7	7-1	"	.53	.25	.06	.026	.005	.003	.005	.003	"	1.10	.16	"	99.7	52.9
8	8-2	"	.82	.66	.56	.27	.10	.026	.006	.003	"	1.06	.14	"	99.7	52.6
9	9-3	"	.92	.70	.58	.36	.12	.036	.008	.004	"	.99	.18	"	99.6	69.9
10	10-4	"	.89	.82	.64	.43	.14	.040	.010	.005	"	1.00	.15	"	99.4	65.0
11	11-5	"	.86	.76	.77	.45	.18	.048	.013	.007	"	1.06	.15	"	99.3	62.1
12	12-6	"	1.07	.92	.77	.54	.25	.053	.014	.007	"	1.02	.15	12.5	99.3	51.0
13	1-7	"	.90	.86	.76	.54	.23	.070	.015	.008	"	1.13	.17	"	99.2	52.6
14	2-8	"	.95	.90	.76	.59	.30	.075	.017	.010	"	1.06	.13	"	98.9	37.7
15	3-9	"	.95	.85	.79	.55	.33	.089	.017	.009	"	1.04	.02	"	99.1	44.3
16	4-10	"	.92	.86	.82	.70	.35	.10	.023	.012	8	1.04	.11	10	98.7	45.3
17	5-11	"	.96	.94	.79	.63	.40	.11	.025	.014	"	1.06	.12	"	98.5	47.1
18	6-12	"	.96	.88	.78	.66	.37	.12	.028	.015	"	1.03	.12	"	98.4	49.3
19	7-1	"	.95	.93	.81	.62	.37	.13	.040	.032	"	1.04	.15	"	96.6	51.6
20	8-2	"	1.04	.90	.86	.69	.41	.14	.035	.023	"	1.00	.14	"	97.6	49.7
21	9-3	"	1.04	.90	.92	.70	.45	.15	.042	.021	7.5	1.08	.11	"	97.8	49.1
22[2]																
23	12-6	"	.91	.72	.45	.16	.027	.005	.0009	.0007	6.5	1.06	.12	"	99.9	50.7
24	1-7	"	.88	.74	.44	.14	.029	.005	.001	.001	"	1.19	.11	"	99.9	54.9
25	2-8	"	.91	.66	.42	.12	.034	.005	.002	.0008	"	1.10	.27	"	99.9	49.4
26	3-9	"	.91	.67	.50	.10	.024	.005	.001	.0006	"	.96	.13	"	99.9	38.1
27	4-10	"	.92	.67	.34	.10	.021	.004	.0009	.0008	"	.91	.16	"	99.9	36.1
28	5-11	"	.85	.68	.30	.079	.015	.003	.0008	.0006	"	1.00	.23	"	99.9	37.0
29	6-12	"	.77	.55	.29	.079	.015	.004	.0009	.0007	"	1.04	.11	"	99.9	43.1
30	7-1	"	.77	.60	.25	.075	.015	.003	.004	.005	"	.98	.13	"	99.4	40.8
31	8-2	"	.77	.54	.26	.071	.015	.006	-	.001	"	.92	.10	"	99.9	42.5

Table A-1, Continued

Complete Data of Resin-in-Pulp Tests
Part 1, Adsorption

Cycle No.	Cells on Ads	Preg Assay	Assay[1] 1	2	3	4	5	6	7	Comp Eff	Barren Volume	Wash Vol	Wash Assay	Time Ads	% Ads	% Load
32	9-3	0.94	.84	.57	.25	.058	.032	.026	.002	.002	6.5	1.02	.11	10	99.8	42.8
33	10-4	"	.62	.54	.22	.050	.010	.002	.001	.0008	"	.92	.13	"	99.9	46.6
34	11-5	"	.94	.56	.16	.043	.004	.002	.0009	.0009	7.0	.99	.093	"	99.9	48.8
35	12-6	"	.81	.51	.17	.045	.011	.003	.002	.0009	"	1.10	.11	"	99.9	46.7
36	1-7	"	.78	.48	.19	.037	.008	.002	.001	.001	"	1.04	.11	"	99.9	47.5
37[3]	2-8	"	.87	.50	.17	.034	.007	.002	.002	.0008	"	.97	.17	"	99.9	44.3
38	3-9	0.77									5.5			"		
39	4-10	"	.62	.43	.21	.057	.016	.004	.005	.001	"	2.00	.06	"	99.9	42.2
40	5-11	"	.59	.33	.15	.043	.014	.004	.001	.001	"	-	-	"	99.9	42.8
41	6-12	"	.42	.29	.16	.041	.014	.003	.001	.002	"	1.70	.05	"	99.7	31.8
42	7-1	"	.54	.30	.14	.060	.017	.010	.009	.005	"	1.56	.05	"	99.4	28.8
43	8-2	"	.67	.40	.17	.052	.017	.010	.005	.004	"	1.92	.05	"	99.5	40.7
44	9-3	"	.58	.35	.16	.053	.017	.010	.007	.006	"	1.84	.05	10	99.2	29.8
45	10-4	"	.68	.40	.17	.065	.019	.008	.004	.004	"	1.70	.06	"	99.5	28.2
46	11-5	"	.73	.46	.26	.070	.021	.008	.006	.002	7.0	1.76	.05	"	99.7	23.4
47	12-6	"	.62	.47	.25	.099	.038	.016	.005	.003	"	2.28	.08	"	99.6	24.9
48	1-7	"	.57	.45	.24	.12	.043	.013	.007	.005	"	2.14	.05	"	99.4	26.0
49	2-8	"	.58	.42	.24	.11	.034	.014	.007	.005	"	1.76	.06	"	99.4	24.3
50	3-9	"	.58	.42	.26	.12	.051	.014	.009	.003	"	1.83	.06	"	99.6	26.5
51	4-10	"	.62	.46	.25	.14	.058	.022	.015	.005	"	1.95	.05	"	99.4	25.0
52	5-11	"	.66	.44	.31	.15	.062	.022	.009	.006	"	1.90	.06	"	99.2	31.0
53	6-12	"	.54	.40	.27	.16	.060	.023	.009	.006	"	1.80	.06	"	99.2	28.0
54	7-1	"	.56	.47	.32	.15	.061	.016	.008	.006	"	1.90	.05	12.5	99.2	30.8
55	8-2	"	.62	.42	.32	.18	.058	.013	.006	.002	6.5	1.96	.04	"	99.7	31.1
56	9-3	"	.63	.59	.32	.15	.067	.019	.007	.006	"	2.02	.06	"	99.2	31.1
57	10-4	"	.70	.52	.29	.12	.054	.013	.005	.003	"	2.00	.07	"	99.6	27.8
58	11-5	"	.75	.54	.40	.14	.054	.017	.014	.004	"	1.64	.09	"	99.5	27.9
59	12-6	"	.71	.56	.32	.084	.038	.014	.004	.003	"	2.06	.05	"	99.6	29.3
60	1-7	"	.73	.57	.32	.14	.048	.018	.008	.002	"	2.14	.05	"	99.7	29.4
61	2-8	"	.72	.57	.33	.16	.058	.019	.009	.006	"	1.87	.08	"	99.2	29.4
62	3-9	"	.63	.57	.48	.13	.037	.016	.012	.004	"	2.08	.04	"	99.5	29.2

[1] Assay

Table A-1, Continued

Complete Data of Resin-in-Pulp Tests
Part 1, Adsorption

Cycle No.	Cells on Ads	Preg Assay	Assay[1/] 1	2	3	4	5	6	7	Comp Eff	Barren Volume	Wash Vol	Wash Assay	Time Ads	% Ads	Load
63	4-10	0.77	.71	.56	.31	.13	.046	.016	.006	.001	6.5	1.60	.09	12.5	99.9	29.2
64	5-11	"	.59	.43	.29	.13	.042	.009	.002	.002	"	2.04	.01	"	99.7	32.0
65	6-12	"	.62	.40	.27	.096	.047	.013	.006	.003	"	2.01	.01	"	99.6	31.1
66	7-1	"	.60	.45	.35	.14	.063	.011	.007	.002	"	1.92	.01	"	99.7	30.0
67	8-2	"	.66	.44	.28	.12	.052	.016	.006	.004	"	2.10	.05	"	99.5	31.1
68	9-3	"	.69	.45	.32	.14	.051	.015	.015	.005	"	2.14	.05	"	99.4	30.6
69	10-4	"	-	.56	.42	.13	.039	.011	.008	.003	"	2.13	.06	"	99.6	30.3
70	11-5	"	.63	.50	.16	.084	.026	.008	.008	.003	"	2.14	.005	"	99.6	32.7
71	12-6	"	.75	.44	.27	.11	.034	.008	.006	.005	"	2.06	.06	"	99.4	31.6
72	1-7	"	.70	.35	.28	.10	.078	.025	.013	.003	"	2.10	.07	"	99.6	28.9
73	2-8	"	.65	.49	.25	.072	.023	.014	.007	.002	"	2.04	.07	"	99.7	28.6
74	3-9	"	.69	.59	.23	.067	.028	.014	.022	.002	"	1.99	.08	"	99.7	29.0
75	4-10	"	.75	.47	.26	.082	.026	.010	.007	.003	"	2.06	.07	"	99.6	29.5
76	5-11	"	-	.55	.47	.076	.028	.018	.003	.003	"	2.01	.13	"	99.6	32.7
77	6-12	"	.53	.46	.16	.067	.035	.008	.005	.004	"	1.85	.08	"	99.5	33.6
78	7-1	"	.68	.46	.19	.094	.036	.016	.007	.006	"	2.19	.07	"	99.2	31.7
79	8-2	"	.73	.52	.22	.11	.034	.010	.008	.004	"	2.06	.07	"	99.5	32.8
80	9-3	"	.65	.51	.31	.13	.063	.013	.012	.003	"	2.08	.07	"	99.6	35.1
81	10-4	"	.73	.44	.33	.11	.033	.013	.009	.005	"	1.93	.06	"	99.4	32.8
82	11-5	"	.65	.51	.29	.13	.042	.013	.009	.005	"	2.13	-	"	99.4	32.8
83	12-6	"	.68	.58	.35	.15	.035	.016	.011	.004	"	2.14	.05	"	99.5	32.3
84	1-7	"	.74	.32	.32	.10	.037	.010	.006	.003	"	2.32	.06	"	99.6	31.2
85	2-8	"	-	-	-	-	-	-	-	-	"	2.12	-	"		29.6
86	3-9	"	.75	.71	.40	.22	.067	.021	.005	.003	"	2.10	.08	"	99.6	31.4
87	4-10	"	.67	.67	.48	.23	.095	.032	.011	.006	"	2.28	.06	"	99.2	32.3
88	5-11	"	.73	.58	.41	.17	.073	.020	.007	.006	"	2.04	.06	"	99.2	33.8
89	6-12	"	.75	.62	.50	.20	.11	.042	.038	.007	"	2.14	.05	"	99.1	33.9
90	7-1	0.49	.47	.42	.33	.18	.084	.014	.013	.007	10.0	2.20	.04	"	98.6	29.4
91	8-2	"	.42	.38	.25	.15	.060	.015	.011	.009	"	2.12	.05	"	98.2	31.9
92	9-3	"	.44	.40	.33	.18	.084	.030	.010	.006	"	2.13	.05	"	98.8	30.2
93	10-4	"	.45	.39	.28	.17	.064	.021	.006	.004	"	1.97	.06	"	99.2	31.8

Table A-1, Continued

Complete Data of Resin-in-Pulp Tests
Part 1, Adsorption

Cycle No.	Cells on Ads	Preg Assay	Assay[1/] 1	2	3	4	5	6	7	Comp Eff	Barren Volume	Wash Vol	Wash Assay	Time Ads	% Ads	% Load
94	11-5	0.49	.44	.37	.22	.13	.050	.017	.006	.004	10.0	2.02	.01	12.5	99.2	29.9
95	12-6	"	.43	.39	.27	.15	.054	.038	.019	.004	"	2.30	.05	"	99.2	29.6
96	1-7	"	.41	.38	.27	.16	.074	.019	.009	.006	"	2.18	.06	"	98.8	27.0
97	2-8	"	.42	.35	.32	.14	.060	.018	.006	.004	"	2.10	.04	"	99.2	27.7
98	3-9	"	.45	.35	.32	.14	.052	.017	.005	.004	"	1.89	.05	"	99.2	38.2
99	4-10	"	.46	.35	.35	.14	.070	.010	.009	.004	"	2.33	.04	"	99.2	31.6
100	5-11	"	.46	.42	.38	.17	.075	.028	.010	.006	"	1.83	.06	"	98.8	31.6
101	6-12	"	.39	.35	.28	.15	.073	.025	.008	.004	"	2.14	.06	"	99.2	33.8
102	7-1	"	.42	.34	.32	.11	.067	.022	.010	.008	"	2.18	.04	"	98.4	31.3
103	8-2	"	.44	.42	.32	.20	.083	.029	.008	.005	"	2.03	.04	"	99.0	31.6
104	9-3	"	.43	.43	.31	.16	.075	.025	.018	.011	"	2.17	.04	"	97.8	28.3
105	10-4	"	.44	.36	.25	.16	.066	.024	.007	.005	"	2.04	.08	"	99.0	30.1
106	11-5	"	.39	.36	.31	.16	.053	.016	.013	.007	"	2.16	.04	"	98.6	29.1
107	12-6	"	.40	.29	.26	.19	.069	.021	.011	.005	"	2.22	.04	"	99.0	28.5
108	1-7	"	.71	.50	.43	.16	.065	.021	.008	.007	"	2.09	.04	"	98.6	28.5
109	2-8	"	.47	.38	.35	.18	.078	.033	.009	.008	"	2.10	.05	"	98.4	32.2
110	3-9	"	.42	.41	.30	.19	.078	.036	.014	.008	"	2.22	.04	"	98.4	31.4
111	4-10	"	.46	.39	.33	.21	.098	.034	.012	.007	"	1.96	-	"	98.6	29.8
112	5-11	"	.46	.43	.32	.14	.094	.036	.014	.011	"	2.06	.04	"	97.8	31.4
113	6-12	"	.44	-	.36	.19	.11	.092	.034	.008	"	2.20	.03	"	98.4	30.9
114	7-1	0.76	.69	.56	.41	.23	.080	.027	.010	.010	7.0	2.10	.07	"	98.7	29.7
115	8-2	"	.51	.49	.41	.18	.051	.026	.019	.014	"	2.10	.06	"	98.2	30.7
116	9-3	"	.70	.53	.46	.24	.094	.024	.019	.009	"	2.00	.05	"	98.8	30.5
117	10-4	"	.92	.62	.50	.25	.12	.042	.018	.008	"	2.09	.06	"	98.9	30.1
118	11-5	"	.75	.49	.40	.21	.066	.021	.007	.004	"	2.07	.06	"	99.5	26.1
119	12-6	"	.66	.50	.31	.20	.070	.027	.013	.008	"	2.14	.06	"	98.9	25.5
120	1-7	"	.72	.55	.39	.24	.068	.031	.024	.019	"	2.14	.04	"	97.5	27.4
121	2-8	"	.61	.53	.37	.26	.10	.090	.048	.016	"	2.04	.04	"	97.9	27.9
122	3-9	"	.72	.43	.41	.13	.075	.025	.018	.014	"	2.06	.05	"	98.2	29.2
123	4-10	"	.47	.40	.24	.17	.071	.031	.018	.008	"	2.00	.05	"	98.9	30.4
124	5-11	"	.47	.35	.20	.15	.039	.022	.021	.018	"	2.00	.05	"	97.6	28.3

Table A-1, Continued

Complete Data of Resin-in-Pulp Tests
Part 1, Adsorption

Cycle No.	Cells on Ads	Preg Assay	Assay[1] 1	2	3	4	5	6	7	Comp Eff	Barren Volume	Wash Vol	Wash Assay	Time Ads	% Ads	Load
125	6-12	0.76	.32	.28	.14	.11	.030	.013	.014	.012	7.0	2.10	.04	12.5	98.4	26.4
126	7-1	0.60	.41	.27	.19	.088	.032	.011	.009	.004	7.5	2.06	.03	"	99.4	26.6
127	8-2	"	.39	.32	.22	.13	.042	.040	.017	.004	10.0	2.06	.04	"	99.4	25.8
128	9-3	"	.46	.46	.44	.34	.044	.026	.018	.011	"	2.10	.04	"	98.2	26.4
129	10-4	"	.38	.33	-	-	-	.025	.011	.008	8.5	2.10	.04	"	98.7	28.2
130	11-5	"	.40	.34	-	-	-	.018	.007	.008	8.5	2.2	.04	"	98.7	27.5
131	12-6	"	.50	.41	-	-	-	.012	.008	.008	"	2.0	.055	"	98.7	26.2
132	1-7	"	.42	.36	-	-	-	.037	.022	.010	"	-	.048	"	98.3	27.3
133	2-8	"	.42	.25	-	-	-	.048	.038	.009	"	-	.048	"	98.5	27.0
134	3-9	"	.47	.35	-	-	-	.035	.012	.012	"	2.06	.044	"	98.0	25.4
135	4-10	"	.45	.34	-	-	-	.024	.012	.011	"	2.1	.032	"	98.2	25.0
136[4]	5-11	"	.50	.38	-	-	-	.033	.014	.012	"	2.04	.033	"	98.0	35.2
137	6-12	"	.48	.42	-	-	-	.041	.013	.012	"	2.14	.057	"	98.0	29.7
138	7-1	"	.37	.37	-	-	-	.034	.014	.013	"	2.15	.044	"	97.8	29.2
139	8-2	"	.52	.42	-	-	-	.048	.016	.009	"	-	.044	"	98.5	24.8
140	9-3	"	.25	.24	-	-	-	.053	.014	.012	"	-	.043	"	98.0	26.5
141	10-4	"	.42	.39	-	-	-	.039	.013	.010	"	2.1	.039	"	98.3	27.6
142	11-5	"	.41	.29	-	-	-	.027	.012	.011	"	2.15	.040	"	98.2	31.4
143	12-6	"	.56	.48	-	-	-	.045	.017	.008	"	2.2	.029	"	98.7	30.0
144	1-7	"	.54	.45	-	-	-	.045	.013	.011	"	2.3	.072	"	98.2	32.8
145	2-8	"	.48	.37	-	-	-	.03	.02	.019	"	2.15	.053	"	96.8	31.1
146	3-9	"	.48	.21	-	-	-	.054	.026	.015	"	2.0	.050	"	97.5	34.3
147	4-10	"	.47	.17	-	-	-	.051	.02	.016	"	1.19	.052	"	97.3	29.1
148	5-11	"	.48	.37	-	-	-	.053	.023	.014	"	2.2	.044	"	97.7	26.8
149	6-12	"	.52	.39	-	-	-	.058	.020	.022	"	2.1	.040	"	96.3	31.7
150	7-1	"	.53	.42	-	-	-	.064	.032	.033	"	2.14	.035	"	94.5	30.6
151	8-2	"	.57	.48	-	-	-	.069	.021	.014	"	2.04	.034	"	97.7	31.6
152	9-3	"	.50	.40	-	-	-	.037	.013	.012	"	2.15	.041	"	98.0	24.0
153	10-4	"	.56	.48	-	-	-	.052	.022	.024	"	2.10	.038	"	96.0	26.4
154	11-5	"	.48	.38	-	-	-	.032	.011	.013	"	2.15	.044	"	97.8	24.4
155	12-6	"	-	-	-	-	-	-	-	.012	"	1.28	.042	"	98.0	28.8
156	1-7	"	.54	-	-	-	-	.049	.018	.017	"	2.12	.055	"	97.2	28.1

Table A-1, Continued

Complete Data of Resin-in-Pulp Tests
Part 1, Adsorption

Cycle No.	Cells on Ads	Preg Assay	Assay[1] 1	2	3	4	5	6	7	Comp Eff	Barren Volume	Wash Vol	Wash Assay	Time Ads	% Ads	Load
157	2-8	0.60	.22	.086	-	-	-	.043	-	.027	8.5	2.06	.044	12.5	95.5	27.4
158	3-9	"	.47	.10	-	-	-	.058	.032	.022	"	2.13	.041	"	96.3	29.0
159	4-10	"	.50	.38	-	-	-	.069	.025	.025	"	2.06	.038	"	95.8	29.2
160	5-11	"	.48	.42	-	-	-	.064	.032	.021	"	2.30	.036	"	96.5	31.2
161	6-12	"	.59	.41	-	-	-	.097	.034	.023	"	2.00	.021	"	96.2	27.9
162	7-1	"	-	.11	-	-	-	.041	.031	.015	"	2.10	.040	"	97.5	31.8
163	8-2	"	.58	.10	-	-	-	.011	-	.023	"	2.08	.043	"	96.2	31.2
164	9-3	"	.63	.54	-	-	-	.10	.037	.034	"	1.96	.042	"	94.3	29.7
165	10-4	"	.49	.44	-	-	-	.085	.042	.025	"	2.00	.052	"	95.8	32.8
166	11-5	"	-	.36	-	-	-	.076	.042	.022	"	2.03	-	"	96.3	29.2
167	12-6	"	.54	.37	-	-	-	.087	.03	.025	"	2.05	.029	"	95.8	32.0
168	1-7	"	.50	.43	-	-	-	.066	.022	.025	"	2.20	.024	"	95.8	28.2
169	2-8	"	.55	.39	-	-	-	.069	.035	.028	"	2.06	.046	"	95.3	30.4
170	3-9	"	.55	.42	-	-	-	.062	.048	.030	"	2.10	.037	"	95.0	29.4
171	4-10	"	.55	.36				.099	.038	.038	"	2.0	.044	"	94.7	25.5
172	5-11	"	-	-				.017	.009	.021	"	2.18	.03	"	96.5	28.5
173	6-12	"	.59	.61				.12	.05	.033	"	2.04	.047	"	94.5	33.2
174	7-1	"	.54	.43				-	.05	.03	"	2.08	.048	15	95.0	26.4
175	8-2	"	.49	.46				.12	.037	.028	"	2.20	.035	"	95.3	29.8
176	9-3	"	.52	.36				.069	.035	.023	"	2.10	.06	"	96.2	26.5
177	10-4	"	.50	.32				.10	.028	.028	"	1.76	.047	"	95.3	21.9
178	11-5	"	.65	.56				.13	.041	.036	"	2.10	.083	"	94.0	25.6
179	12-6	"	.60	.41				.10	.028	.022	"	2.00	.052	"	96.3	24.4
180	1-7	"	.51	.36				.13	.052	-	"	2.14	.043	"	-	19.1
181[5]	2-8	"	.49	.40				.092	.037	.032	"	2.06	.052	"	94.7	23.2
182	3-9	"	.59	.42				.061	.035	.029	"	2.00	.058	12.5	95.2	29.8
183	4-10	"	.48	.41				.063	.035	.025	"	1.98	.043	"	95.8	28.6
184	5-11	"	.46	.44				.09	.025	.025	"	2.00	.047	"	95.8	29.8
185	6-12	"	.54	.50				.077	.019	.018	"	2.00	.044	"	97.0	25.1
186	7-1	"	.60	.49				.109	.031	.028	"	2.18	.035	"	95.3	30.6
187	8-2	"	.57	.50				.072	.018	.017	"	1.96	.052	"	97.2	32.2
188	9-3	"	.57	.62				.064	.017	.011	"	2.10	.041	"	98.2	27.6

Table A-1, Continued

Complete Data of Resin-in-Pulp Tests
Part 1, Adsorption

Cycle No.	Cells on Ads	Preg Assay	Assay[1/] 1	2	3	4	5	6	7	Comp Eff	Barren Volume	Wash Vol	Wash Assay	Time Ads	% Ads	Load
189	10-4	0.59	.68	.56				.020	.019	.012	8.5	1.86	.134	12.5	98.0	35.1
190	11-5	"	.70	.55				.066	.023	.014	"	2.20	.061	"	97.6	31.6
191	12-6	"	.58	.60				.071	.037	.016	"	2.03	.070	"	97.3	26.6
192	1-7	"	.62	.53				.064	-	-	"	2.10	-	"	-	31.6
193	2-8	"	.53	.42				.044	.013	.009	"	1.80	.055	"	98.5	27.8
194	3-9	"	.56	.41				.035	.019	.011	"	2.00	.061	"	98.1	29.4
195	4-10	"	.49	.48				.031	.021	.019	"	2.10	.060	"	96.8	26.3
196	5-11	"	.56	.38				.029	.024	.023	"	2.03	.010	"	96.1	33.5
197	6-12	"	.39	.40				.032	.013	.012	"	2.06	.058	"	98.0	32.4
198	7-1	"	.55	.35				.024	.017	.013	"	2.04	.056	"	97.8	31.1
199	8-2	"	.54	.30				.015	.015	.005	"	2.00	.060	"	99.2	31.0
200	9-3	"	.49	.39				.009	.006	.006	"	2.12	.008	"	99.0	32.4
201	10-4	"	.40	.33				.012	.013	.011	"	2.10	.060	"	98.1	28.1
202	11-5	"	.41	.22				.105	-	.004	"	2.20	.052	"	99.3	25.8
203	12-6	"	.46	.22				.012	.007	.004	"	2.14	.039	"	99.3	24.7
204	1-7	"	.52	.35				.004	.002	.001	"	-	.060	"	99.8	28.3
205	2-8	"	.51	.38				.014	.012	.004	"	2.00	.046	"	99.3	21.5
206	3-9	"	.56	.46				.013	.008	.006	"	2.14	.042	"	99.0	30.8
207	4-10	"	.56	.37				.016	.029	.003	"	2.06	.061	"	99.5	28.6
208	5-11	"	.46	.33				.002	.002	.004	"	2.16	.06	"	99.3	26.6
209	6-12	"	.54	.27				.013	.008	.011	"	1.96	.05	"	98.1	33.8
210	7-1	"	.48	.17				.01	.005	.007	"	2.10	.005	"	98.8	28.0
211	8-2	"	.43	.32				.095	.008	.004	"	1.94	.046	"	99.3	33.6
212	9-3	"	.44	.30				.017	.008	.004	"	2.04	.039	"	99.3	28.1
213	10-4	"	.43	.38				.009	.004	.003	"	1.90	.061	"	99.5	26.1
214	11-5	"	.51	.37				.013	.013	.006	"	2.11	.061	"	99.0	23.6
215	12-6	"	.49	.50				.013	.011	.004	"	2.08	.051	"	99.3	22.6
216	1-7	"	.45	.41				.038	.019	.008	"	2.06	.063	"	98.6	26.8
217	2-8	"	.46	.31				.044	.024	.013	"	2.15	.036	"	97.8	23.1
218	3-9	"	.59	.50				.17	.005	.004	"	1.96	.046	"	99.3	33.6
219	4-10	"	.46	.23				.12	.03	.01	"	2.10	.07	"	98.3	25.8
220	5-11	"	.48	-				-	.01	.008	"	1.99	.084	"	98.6	25.8

Table A-1, Continued

Complete Data of Resin-in-Pulp Tests
Part 1, Adsorption

Cycle No.	Cells on Ads	Preg Assay	Assay[1] 1	2	3	4	5	6	7	Comp Eff	Barren Volume	Wash Vol	Wash Assay	Time Ads	% Ads	Load
221	6-12	0.59	.47	.31				.028	.02	.011	8.5	2.20	.037	12.5	98.1	28.2
222	7-1	"	.49	.28				.01	.015	.007	"	1.98	.051	"	98.8	24.8
223	8-2	"	.52	.51				.013	.006	.004	"	2.00	.044	"	99.3	28.2
224	9-3	"	.49	.40				.008	.005	.005	"	2.00	.037	"	99.0	25.4
225	10-4	"	-	.41				.008	.006	.003	"	2.08	.052	"	99.5	26.7
226	11-5	"	.58	.26				.011	.009	.004	"	2.16	.060	"	99.3	23.7
227	12-6	"	.48	.35				.016	.011	.007	"	1.95	.059	"	98.8	28.3
228	1-7	"	.40	.10				.013	.010	.005	"	2.04	.040	"	99.0	26.3
229	2-8	"	.44	.41				.021	.008	.007	"	1.88	.047	"	98.8	25.6
230	3-9	"	.50	.29				.013	.008	.005	"	2.10	.039	"	99.0	27.6
231	4-10	"	.44	.32				.011	.01	.006	"	2.60	.047	"	99.0	28.3
232	5-11	"	.50	.38				.008	.002	.008	"	2.10	.008	"	98.6	24.4
233	6-12	"	.56	.32				.15	.091	.007	"	2.04	.036	"	98.8	27.7
234	7-1	"	.32	.25				.15	.009	.007	"	2.04	.059	"	98.8	28.5
235	8-2	"	.57	.41				-	.008	.006	"	2.20	.043	"	99.0	23.6
236	9-3	"	.32	.11				.038	.012	.008	"	2.20	.041	"	98.6	27.2
237	10-4	"	.54	.46				.021	.010	.006	"	2.00	.051	"	99.0	26.3
238	11-5	"	.64	.40				.023	.032	.018	"	2.00	.058	"	97.0	28.7
239	12-6	"	.56	.37				.029	.016	.012	"	1.12	.30	"	97.6	31.7
240	1-7	"	.26	.33				.041	.021	.012	"	2.06	.048	"	97.6	26.4
241	2-8	"	.45	-				.046	.031	.011	"	2.14	.044	"	98.1	23.8
242	3-9	"	.36	.36				.028	.012	.013	"	2.03	.049	"	97.8	24.8
243	4-10	"	.47	.30				.029	.018	.009	"	2.02	.048	"	98.5	24.8
244	5-11	"	.42	.39				.032	.019	.015	"	1.98	.055	"	97.5	25.4
245[6]	6-12	"	.42	.45				.043	.013	.010	"	2.02	.029	"	98.3	24.4
246	7-1	"	.46	.40				.058	.023	.017	"	2.04	.063	"	97.1	22.4
247	8-2	"	.43	.39				.041	.017	.019	"	2.00	.054	"	96.8	23.6
248	9-3	"	.52	.47				.045	.02	.020	"	2.20	.043	"	96.7	23.8
249	10-4	"	.64	.47				.051	.028	.017	"	1.64	.058	"	97.1	23.3
250	11-5	"	.58	.52				.062	.027	.012	"	2.02	.052	"	97.6	24.1
251	12-6	"	.67	.42				.053	.017	.017	"	2.10	.045	"	97.1	22.6
252	1-7	"	.62	.44				.050	.030	.021	"	1.04	.059	"	96.4	24.3

Table A-1, Continued

Complete Data of Resin-in-Pulp Tests
Part 1, Adsorption

Cycle No.	Cells on Ads	Preg Assay	Assay[1] 1	2	3	4	5	6	7	Comp Eff	Barren Volume	Wash Vol	Wash Assay	Time Ads	% Ads	Load
253	2-8	0.59	.58	.39				.063	.030	.013	8.5	2.00	.11	12.5	97.8	19.9
254	3-9	"	.50	.39				.053	.025	.016	"	2.04	.054	"	97.3	20.2
255	4-10	"	.58	.42				.033	.021	.010	"	2.14	.047	"	98.3	20.8
256	5-11	"	.54	.34				.026	.022	.015	"	2.06	.040	"	97.5	23.0
257	6-12	"	.65	.51				.072	.029	.019	"	2.00	.049	"	96.8	22.9
258	7-1	"	.64	.44				.058	.052	.029	"	2.02	.051	"	95.1	25.0
259	8-2	"	.50	.49				.071	.039	.031	"	2.00	.070	"	94.7	24.8
260	9-3	"	.60	.56				.085	.038	.033	"	2.06	.04	"	94.4	23.3
261	10-4	"	.60	.49				.075	.031	.027	"	2.04	.05	"	95.4	24.8
262	11-5	0.58	.56	.40				.057	.026	.019	"	2.04	.05	"	96.7	31.1
263	12-6	"	.61	.49				.070	.029	.018	"	2.08	.05	"	96.9	24.7
264	1-7	"	.61	.53				.064	.020	.009	7.5	2.00	.06	"	98.4	24.7
265	2-8	"	.62	.43				.063	.033	.021	"	2.00	.06	"	96.4	23.6
266	3-9	"	.59	.46				.058	.021	.017	"	2.00	.07	"	97.1	22.4
267	4-10	"	.50	.48				.062	.033	.018	"	2.06	.04	"	96.9	25.4
268	5-11	"	.58	.42				.053	.029	.019	"	2.14	.05	"	96.7	24.9
269	6-12	"	.52	.37				.031	.017	.013	"	1.98	.05	"	97.8	25.5
270	7-1	"	.59	.41				.050	.023	.017	"	2.08	-	"	97.1	26.2
271	8-2	"	.54	.36				.049	.026	.018	"	1.98	.04	"	96.9	23.6
272	9-3	"	.57	.49				.050	.028	.025	"	1.98	.04	"	95.7	25.6
273	10-4	"	.56	.44				.070	.032	.021	"	1.98	.05	"	96.4	27.1
274	11-5	"	.60	.36				.041	.039	.015	8.0			"	97.4	25.7
275[7]	12-6	"	.58	.48				.037	.016	.010	"			"	98.3	26.7
276	1-7	"	.60	.36				.053	.038	.012	"			"	97.9	26.9
277	2-8	"	.58	.44				.045	.018	.017	"			"	97.1	29.2
278	3-9	"	.54	.48				.055	.030	.011	"			"	98.1	26.2
279	4-10	"	.57	.43				.041	-	.012	"			"	97.9	22.9
280	5-11	"	.54	.46				.045	.012	.011	"			"	98.1	28.2
281	6-12	"	.53	.53				.058	.043	.012	"			"	97.9	23.6
282	7-1	"	.59	.39				.040	.019	.012	"			"	97.9	24.1
283	8-2	"	.56	.43				.051	.049	.036	"			"	93.8	25.0
284	9-3	"	.54	.40				.068	.033	.032	"			"	94.5	26.6

Table A-1, Continued

Complete Data of Resin-in-Pulp Tests
Part 1, Adsorption

Cycle No.	Cells on Ads	Preg Assay	Assay[1] 1	2	3	4	5	6	7	Comp Eff	Barren Volume	Wash Vol	Wash Assay	Time Ads	% Ads	Load
285	10-4	0.58	.58	.42				.090	.036	.031	8.0			12.5	94.7	28.4
286	11-5	"	.57	.45				.063	.036	.028	"			"	95.2	25.6
287	12-6	"	.58	.39				.048	.024	.019	"			"	96.7	27.7
288	1-7	"	.54	.37				.048	.025	.020	"			"	96.5	26.4
289	2-8	"	.48	.44				.068	.052	.022	"			"	96.2	24.5
290	3-9	"	.55	.34				.11	.077	.036	"			"	93.8	25.5
291	4-10	"	.49	.34				.082	.035	.017	"			"	97.1	25.1
292	5-11	"	.66	.59				.083	.037	.022	"			"	96.2	25.6
293	6-12	"	.56	.53				.078	.036	.021	"			"	96.4	25.6
294	7-1	"	.55	.49				.057	.027	.017	"			"	97.1	27.2
295	8-2	"	.57	.45				.057	.029	.021	"			"	96.4	27.3
296	9-3	"	.61	.49				.053	.033	.021	"			"	96.4	27.3
297	10-4	"	.66	.49				.073	.034	.023	"			"	96.0	27.1
298	11-5	"	.64	.47				.075	-	.025	"			"	95.7	27.2
299	12-6	"	.58	.55				.061	.028	.023	"			"	96.0	26.5
300	1-7	"	-	-				-	-	-	"			"		23.9
301	2-8	"	.60	.46				.056	.022	.015	"			"	97.4	24.4
302	3-9	"	.50	.45				.058	.042	.029	"			"	95.0	24.4
303	4-10	"	.47	.37				.057	.024	.020	"			"	96.5	23.2
304	5-11	"	.58	.40				.047	.027	.024	"			"	95.9	24.0
305	6-12	"	.63	.43				.066	.025	.021	"			"	96.4	25.4
306	7-1	"	-	.39				.046	.035	.030	"			"	94.8	26.0
307	8-2	"	.53	.46				.10	.056	.024	"			"	95.9	24.7
308	9-3	"	.57	.37				.069	.033	.018	"			"	96.9	23.7

Table A-1

Complete Data of Resin-in-Pulp Tests
Part II, Elution

Cycle No.	Cells on Elution	Assay[1] 1	2	3	4	5	El. Comp	Eluate Volume	Wash Vol	Wash Assay	Time Elution
1)											
2)											
3)	No data for these first cycles because system being filled.										
4)											
5)											
6	1-4	.26	1.48	4.00	7.30		7.68	1.06	1.00	.023	30
7	2-5	.38	1.26	3.73	6.95		7.52	1.02	1.00	.029	"
8	3-6	.29	1.12	3.42	6.75		6.87	1.11	1.06	.27	"
9	4-7	.24	.94	2.66	5.61		6.62	1.53	1.00	.018	"
10	5-8	.18	.64	2.34	4.73		6.32	1.49	1.10	.012	"
11	6-9	.16	.46	1.58	4.18		5.85	1.54	.90	.013	"
12	7-11	.083	.26	1.00	3.52	6.70	7.18	1.03	1.00	.006	"
13	8-12	.069	.32	1.02	2.86	5.96	7.00	1.09	.95	.007	"
14	9-1	.067	.32	1.13	2.84	5.48	5.64	.97	1.08	.005	"
15	10-2	.085	.35	.95	3.00	6.01	6.90	.93	1.05	.007	"
16	11-3	.10	.38	1.16	3.05	6.31	7.06	.93	1.09	.008	"
17	12-4	.10	.41	1.38	3.26	6.32	7.34	.93	1.08	.011	"
18	1-5	.098	.50	1.20	6.40	7.02	7.45	.96	1.17	.012	"
19	2-6	.13	.49	1.20	3.14	6.44	7.56	.99	1.01	.012	"
20	3-7	.10	.43	1.17	3.37	6.31	7.27	.99	1.05	.012	"
21[2]	4-8	.086	.33	1.08	2.68	5.28	6.41	1.11	1.06	.007	"
22[2]	5-9	.063	.42	.94	2.51	5.76	6.39	1.15	.95	.005	"
23											
24	8-12	.023	.16	.50	1.64	5.25	6.80	1.17	.98	.003	"
25	9-1	.034	.099	.38	1.51	5.60	6.02	1.19	1.02	.006	"
26	10-2	.024	.14	.56	1.96	4.43	4.12	1.34	.99	.004	"
27	11-3	.023	.16	.67	2.00	4.76	5.08	1.03	.96	.003	"
28	12-4	.041	.22	.81	2.20	5.00	5.20	1.03	1.00	.005	"
29	1-5	.042	.23	.64	1.82	5.14	6.01	1.04	1.14	.005	"
30	2-6	.061	.24	.86	2.48	5.49	5.80	1.02	1.00	.006	"
31	3-7	.059	.25	.94	2.96	5.53	5.81	1.06	1.00	.008	"

Table A-1, Cont'd

Complete Data of Resin-in-Pulp Tests
Part II, Elution

Cycle No.	Cells on Elution	Assay[1] 1	2	3	4	5	El. Comp	Eluate Volume	Wash Vol	Wash Assay	Time Elution
32	4-8	.12	.32	.98	2.68	5.57	6.14	1.01	.96	.007	30
33	5-9	.085	.33	.98	2.67	5.56	6.50	1.04	.98	.008	"
34	6-10	.098	.33	1.08	3.00	5.58	6.80	1.04	.96	.053	"
35	7-11	.11	.51	1.39	2.82	5.40	6.38	1.06	1.02	.010	"
36	8-12	.11	.38	1.00	2.62	5.53	6.68	1.03	1.02	.010	"
37[3]	9-1	.15	.38	1.21	2.83	5.53	6.06	1.06	1.00	.008	"
38	10-2										"
39	11-3	.023	.16	.86	2.76	5.60	5.88	1.04	1.04	.002	"
40	12-4	.068	.28	1.02	2.79	5.16	5.55	1.12	-	-	"
41	1-5	.058	.29	.90	2.19	4.17	4.52	1.02	1.08	.006	"
42	2-6	.069	.24	.86	2.07	4.07	4.14	1.01	1.06	.008	"
43	3-7	.12	.39	.89	2.13	3.80	5.31	1.11	.96	.008	"
44	4-8	.090	.33	.93	2.14	3.56	3.76	1.15	1.00	.008	"
45	5-9	.093	.32	.90	1.94	3.42	3.58	1.14	.96	.008	"
46	6-10	.061	.23	.54	1.48	2.95	3.26	1.04	1.00	.006	"
47	7-11	.058	.19	.56	1.46	3.01	3.41	1.06	.92	.006	"
48	8-12	.070	.25	.56	1.46	2.99	3.31	1.14	1.00	.005	"
49	9-1	.086	.21	.58	1.78	3.01	3.32	1.06	1.02	-	"
50	10-2	.091	.23	.83	1.74	3.21	3.62	1.06	.92	.007	"
51	11-3	.057	.25	.69	1.74	3.39	3.63	1.00	.93	.005	"
52	12-4	.058	.25	.71	1.78	3.30	3.74	1.20	.96	.031	"
53	1-5	.097	.28	.69	1.94	3.78	4.05	1.00	1.02	.010	"
54	2-6	.074	.28	.85	1.72	3.86	4.22	1.06	1.00	.007	"
55	3-7	.075	.27	.86	2.17	3.65	4.25	1.06	1.02	.014	"
56	4-8	.090	.28	.96	1.85	3.42	4.38	1.03	.96	.008	"
57	5-9	.062	.27	.80	1.68	3.46	3.87	1.04	1.02	.007	"
58	6-10	.091	.27	.69	1.91	3.52	3.88	1.04	.94	.004	"
59	7-11	.068	.35	.85	1.94	3.75	4.25	1.00	1.06	.003	"
60	8-12	.088	.36	.71	1.75	3.50	4.10	1.04	1.00	.004	"
61	9-1	.056	.25	.63	1.60	3.28	3.88	1.10	1.01	.003	"
62	10-2	.045	.11	.34	1.70	3.52	4.15	1.02	.92	.002	"

Table A-1, Cont'd

Complete Data of Resin-in-Pulp Tests
Part II, Elution

Cycle No.	Cells on Elution	Assay[1/] 1	2	3	4	5	El. Comp	Eluate Volume	Wash Vol	Wash Assay	Time Elution
63	11-3	.026	.11	.55	1.63	3.63	4.15	1.02	1.00	.002	30
64	12-4	.029	.13	.51	1.35	3.20	4.37	1.06	.96	.002	"
65	1-5	.055	.20	.56	1.35	3.20	4.34	1.04	1.10	.003	"
66	2-6	.077	.19	.64	1.61	3.54	4.35	1.00	.82	.007	"
67	3-7	.052	.24	.68	1.86	3.78	4.42	1.02	1.02	.003	"
68	4-8	.073	.20	.68	1.87	3.30	4.26	1.04	1.02	.003	"
69	5-9	.068	.24	.75	-	3.39	4.39	1.00	1.04	.003	"
70	6-10	.094	.27	.70	2.07	3.41	4.60	1.03	1.08	.003	"
71	7-11	.10	.33	.79	2.27	3.32	4.17	1.10	1.10	.004	"
72	8-12	.053	.21	.57	1.65	3.31	4.10	1.02	1.06	.003	"
73	9-1	.050	.23	.69	2.04	2.85	3.91	1.06	1.04	.002	"
74	10-2	.081	.26	1.06	2.70	3.34	4.20	1.00	.96	.004	"
75	11-3	.10	.41	.69	2.52	4.10	4.28	1.00	1.14	.002	"
76	12-4	.11	.30	1.09	2.78	4.10	4.74	1.00	1.08	.004	"
77	1-5	.12	.38	1.01	2.58	3.48	4.59	1.06	.94	.007	"
78	2-6	.04	.41	1.08	3.03	3.89	4.51	1.02	1.11	.006	"
79	3-7	.11	.69	.98	3.58	4.35	4.58	1.04	.93	.004	"
80	4-8	.11	.41	.92	2.41	4.02	4.89	1.04	1.08	.002	"
81	5-9	.15	.35	1.04	2.59	4.25	4.58	1.04	1.00	.002	"
82	6-10	.12	.32	1.00	2.40	3.96	4.66	1.02	1.06	.004	"
83	7-11	.12	.32	.87	2.28	4.20	4.59	1.02	1.10	.007	"
84	8-12	.085	.29	.89	2.56	4.36	4.43	1.02	1.03	.007	"
85	9-1	.10	.33	.71	2.28	3.50	4.28	1.00	1.04	.008	"
86	10-2	.088	-	.77	2.20	4.23	4.50	1.01	.97	.006	"
87	11-3	.078	.31	.84	2.78	3.69	4.34	1.08	1.06	.004	"
88	12-4	.082	.27	.88	2.12	3.87	4.45	1.10	1.00	.007	"
89	1-5	.16	.31	.73	2.06	3.77	4.63	1.06	1.00	.059	"
90	2-6	.092	.29	.77	2.08	3.88	4.21	1.01	1.10	.013	"
91	3-7	.088	.24	.70	1.87	3.68	4.28	1.08	1.03	.008	"
92	4-8	.073	.15	.58	1.94	3.68	4.29	1.02	1.08	.008	"
93	5-9	.084	.24	1.03	2.00	3.85	4.44	1.04	1.08	.003	"

Table A-1, Cont'd

Complete Data of Resin-in-Pulp Tests
Part II, Elution

Cycle No.	Cells on Elution	Assay[1/] 1	2	3	4	5	El. Comp	Eluate Volume	Wash Vol	Wash Assay	Time Elution
94	6-10	.082	.29	.58	1.87	3.59	4.33	1.00	1.04	.004	30
95	7-11	.060	.25	.76	2.26	3.56	4.29	1.00	1.04	.004	"
96	8-12	.064	.16	.76	1.66	3.48	3.87	1.01	.94	.002	"
97	9-1	.063	.25	.52	2.05	3.92	4.06	.99	1.08	.002	"
98	10-2	.056	.19	.73	2.29	3.78	4.81	1.15	.92	.002	"
99	11-3	.051	.22	1.18	1.82	3.78	4.49	1.02	1.08	.003	"
100	12-4	.064	.24	.68	1.93	3.65	4.49	1.02	.87	.003	"
101	1-5	.090	.22	.81	2.27	3.92	4.90	1.00	1.14	.003	"
102	2-6	.19	.32	1.07	2.28	3.92	4.54	1.00	1.06	.003	"
103	3-7	.12	.41	.86	2.13	3.74	4.58	1.00	1.11	-	"
104	4-8	.13	.32	.75	1.72	3.61	4.22	.97	1.05	.007	"
105	5-9	.092	.30	.75	1.88	3.66	4.54	.96	1.08	.003	"
106	6-10	.11	.36	1.05	2.27	4.18	4.30	.98	1.10	.004	"
107	7-11	.076	.26	.82	2.00	4.09	4.32	.99	1.10	.004	"
108	8-12	.071	.25	.50	1.91	3.73	4.22	.98	1.06	.003	"
109	9-1	.073	.25	.71	1.85	3.60	4.49	1.04	1.09	.018	"
110	10-2	.049	.18	1.04	1.20	4.00	4.51	1.01	.96	.005	"
111	11-3	.055	.22	.80	1.64	3.46	4.15	1.04	1.08	.002	"
112	12-4	.081	.32	.72	2.00	4.00	4.47	1.02	1.04	.004	"
113	1-5	.11	.30	.80	2.48	4.16	4.57	.98	1.14	.005	"
114	2-6	.076	.26	.89	2.30	2.82	4.40	.98	1.08	.006	"
115	3-7	.24	.38	.81	1.86	3.47	4.05	1.10	1.04	.005	"
116	4-8	.18	.32	.78	1.87	3.80	4.42	1.00	1.03	.007	"
117	5-9	.085	.27	.74	1.62	3.90	4.36	1.00	1.03	.006	"
118	6-10	.18	.22	.77	1.60	3.32	3.78	1.00	1.04	.008	"
119	7-11	.12	.27	.68	1.72	3.58	3.85	.96	1.06	.006	"
120	8-12	.14	.34	.72	1.90	3.70	4.05	.98	1.06	.007	"
121	9-11	.11	.27	.71	2.52	3.34	4.05	1.00	1.10	.005	"
122	10-2	.096	.14	.90	1.62	3.58	4.31	.98	.95	.005	"
123	11-3	.091	.37	.75	2.93	3.67	4.45	.99	1.14	.009	"

Table A-1, Cont'd

Complete Data of Resin-in-Pulp Tests
Part II, Elution

Cycle No.	Cells on Elution	Assay[1] 1	2	3	4	5	El. Comp	Eluate Volume	Wash Vol	Wash Assay	Time Elution
124	12-4	.090	.37	1.56	2.98	3.62	3.94	1.04	1.05	.023	30
125	1-5	.10	.96	1.25	2.50	3.74	3.86	.99	1.10	.007	"
126	2-6	.18	1.37	1.38	2.18	3.40	3.86	1.00	1.12	.014	"
127	3-7	.20	.32	1.80	2.15	3.26	3.82	.98	1.02	.051	"
128	4-8	.092	.51	.86	1.91	3.66	3.75	1.02	.99	.019	"
129	5-9	.086	-	-	-	-	3.87	1.07	1.04	.004	"
130	6-10	.04	-	-	-	-	3.83	1.04	1.02	.007	"
131	7-11	.038	-	-	-	-	3.80	1.0	-	.027	"
132	8-12	.10	-	-	-	-	3.96	1.0	-	.015	"
133	9-1	.041	-	-	-	-	3.91	1.0	-	.004	"
134	10-2	.043	-	-	-	-	3.62	1.02	.93	.001	"
135	11-3	.052	-	-	-	-	3.70	.98	1.04	.002	"
136[4]	12-4	.016	.075	.386	.94	2.49	4.92	1.04	1.06	.003	"
137	1-5	.034	.13	.92	1.33	2.70	4.14	1.04	1.1	.002	"
138	2-6	.03	.14	.49	1.28	2.39	3.86	1.1	1.06	.002	"
139	3-7	.035	.17	.60	1.13	3.08	3.60	1.0	-	.003	"
140	4-8	.088	.26	.65	2.04	3.39	3.84	1.0	-	.004	"
141	5-9	.042	.11	.70	2.22	4.25	4.00	1.0	.96	.002	"
142	6-10	.052	.23	.59	1.33	2.66	4.65	.98	1.03	.002	"
143	7-11	.045	.29	.57	1.70	2.54	4.26	1.02	1.0	.002	"
144	8-12	.064	.23	.60	1.13	2.30	3.90	1.22	.98	.004	"
145	9-1	.12	.19	.31	.91	2.17	3.76	1.2	1.04	.002	"
146	10-2	.035	.14	.44	1.28	2.61	4.11	1.21	.94	.002	"
147	11-3	.038	.13	.50	1.32	2.88	3.73	1.13	.90	.002	"
148	12-4	.039	.24	.44	1.25	3.12	3.53	1.10	1.13	.002	"
149	1-5	.050	.21	.47	1.85	3.25	4.22	1.09	1.10	.001	"
150	2-6	.038	.18	.71	1.58	2.42	4.26	1.04	1.20	.005	"
151	3-7	-	-	.60	1.43	2.56	4.09	1.12	1.02	.002	"
152	4-8	.045	.17	.23	2.22	2.74	3.48	1.00	1.08	.014	"
153	5-9	.078	.20	.52	1.60	2.70	3.84	1.00	1.00	.019	"
154	6-10	.059	.22	.68	1.18	-	3.44	1.03	1.40	.020	"
155	7-11	-	.20	.52	1.48	-	4.10	1.02	.90	.004	"

Table A-1, Cont'd

Complete Data of Resin-in-Pulp Tests
Part II, Elution

Cycle No.	Cells on Elution	Assay[1] 1	2	3	4	5	El. Comp	Eluate Volume	Wash Vol	Wash Assay	Time Elution
156	8-12	.043	.19	.43	.72	2.82	4.00	1.02	.93	-	30
157	9-1	.02	.20	.41	1.31	2.78	3.82	1.04	1.09	-	"
158	10-2	.068	.22	.52	1.58	3.26	4.12	1.02	.97	.005	"
159	11-3	-	-	-	-	-	4.24	1.00	1.04	.021	"
160	12-4	.099	.24	.59	2.04	2.90	4.27	1.06	1.04	.002	"
161	1-5	.045	.21	.64	2.08	3.20	3.82	1.06	1.10	.004	"
162	2-6	.034	.17	.62	1.42	1.82	4.28	1.08	1.04	.003	"
163	3-7	.03	.28	.72	1.63	3.14	4.52	1.00	.95	.003	"
164	4-8	-	.41	.86	1.80	2.92	4.34	.995	1.00	.004	"
165	5-9	.15	.20	.72	1.58	2.88	4.87	.98	1.10	.036	"
166	6-10	.048	.21	.62	1.32	2.36	4.32	.98	1.10	.004	"
167	7-11	.054	.20	.49	1.70	2.16	4.11	1.13	1.10	.003	"
168	8-12	.047	.20	.81	.97	1.93	3.50	1.17	.98	.02	"
169	9-1	.038	-	.38	1.06	2.56	4.12	1.07	1.10	.038	"
170	10-2	.021	.14	.39	1.51	2.64	3.88	1.10	.95	.002	"
171	11-3	.015	.16	.37	1.55	3.14	3.70	1.0	1.08	.001	"
172	12-4	.050	.19	.56	1.78	3.62	4.22	.98	1.08	.002	"
173	1-5	.17	.59	.78	1.90	3.32	4.86	.99	1.10	.004	"
174	2-6	.041	.175	.625	1.44	2.74	4.71	.81	1.04	.003	"
175	3-7	-	.13	-	1.55	2.78	3.55	1.22	1.05	.004	"
176	4-8	.06	.22	.65	1.76	3.48	4.80	.80	1.70	.004	"
177	5-9	.067	.20	.66	1.21	3.42	3.82	.83	0.96	.004	"
178	6-10	.036	.24	.78	1.91	3.04	4.22	.88	1.05	.014	"
179	7-11	.056	.23	.81	3.32	3.26	4.44	.80	1.00	.021	"
180[5]	8-12	.066	.28	1.90	3.42	3.20	3.30	.84	0.94	.004	"
181[5]	9-1	.068	.27	.82	1.87	3.41	4.05	.83	1.04	.005	"
182	10-2	.093	.36	.93	2.61	3.84	5.04	.86	1.00	.011	"
183	11-3	.072	.54	.98	2.04	3.37	5.11	.81	1.00	.005	"
184	12-4	.08	.42	1.08	2.54	3.26	5.40	.80	1.00	.004	"
185	1-5	.088	.58	1.50	2.62	3.33	4.44	.82	1.20	.010	"
186	2-6	.080	.32	1.14	1.76	3.24	5.48	.81	1.04	.007	"

Table A-1, Cont'd

Complete Data of Resin-in-Pulp Tests
Part II, Elution

Cycle No.	Cells on Elution	Assay[1/] 1	2	3	4	5	El. Comp	Eluate Volume	Wash Vol	Wash Assay	Time Elution
187	3-7	.110	.384	1.00	2.00	3.27	5.64	.83	1.00	.006	30
188	4-8	.058	.158	1.01	1.28	2.38	4.55	.88	1.00	.003	"
189	5-9	.083	.282	.94	2.02	3.68	6.25	.815	1.00	.007	"
190	6-10	.13	.30	.86	1.68	3.85	5.88	.78	1.06	.013	"
191	7-11	.053	.38	.72	1.48	2.82	4.30	.90	0.99	.005	"
192	8-12	.088	.31	.52	1.43	3.34	5.67	.81	0.93	.006	"
193	9-1	.14	.21	.66	2.20	3.30	4.86	.83	1.10	.005	"
194	10-2	.048	.190	.86	1.80	3.88	4.36	.795	0.96	.005	"
195	11-3	.078	.290	.68	1.79	3.63	4.65	.82	1.10	.005	"
196	12-4	.13	.28	1.21	2.04	3.97	5.79	.84	0.96	.005	"
197	1-5	.11	.31	.87	2.04	2.68	5.75	.815	1.10	.008	"
198	2-6	.10	.36	1.02	1.77	3.40	5.65	.80	1.04	.006	"
199	3-7	.12	.39	.92	1.96	3.85	5.36	.84	1.03	.006	"
200	4-8	.135	.36	.98	1.26	3.46	5.86	.80	0.99	.008	"
201	5-9	.104	.44	1.08	2.10	3.99	4.58	.89	0.99	.010	"
202	6-10	.140	.40	.96	2.38	4.32	4.67	.80	1.00	0.15	"
203	7-11	.124	-	1.00	2.32	4.08	4.48	.80	1.10	.005	"
204	8-12	.088	.34	.88	2.16	4.32	5.13	.80	1.04	.006	"
205	9-1	.08	.236	.84	2.66	4.16	-	.80	1.00	.003	"
206	10-2	.079	.30	1.03	2.85	3.77	5.57	.80	.97	.017	"
207	11-3	.11	.21	1.56	2.80	4.08	4.60	.90	1.03	.005	"
208	12-4	.083	.46	1.03	2.28	3.62	4.56	.83	1.02	.008	"
209	1-5	.153	.45	1.00	2.25	3.74	5.45	.90	1.15	.010	"
210	2-6	.160	.45	1.13	2.93	3.68	5.20	.78	1.11	.009	"
211	3-7	.17	.52	1.04	2.22	3.15	4.44	1.10	1.03	.005	"
212	4-8	.13	.44	1.02	1.95	3.71	5.04	.81	1.10	.006	"
213	5-9	.077	.46	1.28	2.18	4.24	5.24	.725	1.02	.005	"
214	6-10	.15	.43	.99	2.68	3.76	4.90	.70	1.00	.007	"
215	7-11	.16	.61	1.44	2.92	4.36	4.56	.72	1.04	.007	"
216	8-12	.23	.40	1.54	2.82	4.00	5.47	.71	1.06	.007	"
217	9-1	.19	.53	1.39	2.50	4.48	4.70	.715	1.00	.008	"

Table A-1, Cont'd

Complete Data of Resin-in-Pulp Tests
Part II, Elution

Cycle No.	Cells on Elution	Assay[1] 1	2	3	4	5	El. Comp	Eluate Volume	Wash Vol	Wash Assay	Time Elution
218	10-2	.045	.41	1.09	2.50	4.00	4.88	1.00	.95	.004	30
219	11-3	.16	.51	1.23	2.26	3.94	5.41	.69	1.00	.005	"
220	12-4	.15	.61	1.25	2.92	5.00	5.34	.70	1.00	.006	"
221	1-5	.22	.67	1.38	2.62	4.92	5.24	.78	1.08	.009	"
222	2-6	.19	.66	1.18	3.18	4.90	5.04	.715	1.00	.008	"
223	3-7	.24	.75	2.02	3.72	4.92	5.85	.70	.93	.001	"
224	4-8	.40	1.09	1.98	1.64	4.84	5.27	.70	.95	.032	"
225	5-9	.36	.78	1.74	3.70	3.94	5.53	.70	1.02	.010	"
226	6-10	.22	.82	1.91	2.86	4.72	4.91	.70	1.00	.012	"
227	7-11	.27	.76	1.59	3.06	4.12	5.90	.695	-	.012	"
228	8-12	.42	.78	1.65	2.92	4.24	5.30	.72	1.02	.024	"
229	9-1	.21	.86	1.62	3.58	3.80	4.88	.76	1.08	.010	"
230	10-2	.13	.77	1.72	2.72	4.68	5.42	.74	.92	.010	"
231	11-3	.26	.78	1.84	3.16	4.60	5.46	.75	1.05	.007	"
232	12-4	.18	.69	2.03	3.56	3.53	4.60	.77	1.08	.008	"
233	1-5	.24	.76	1.25	2.66	4.16	5.44	.74	1.06	.012	"
234	2-6	.18	.99	1.91	2.44	3.53	5.44	.76	1.06	.013	"
235	3-7	.51	.86	1.19	2.26	3.74	4.50	.76	1.00	.003	"
236	4-8	.78	.64	-	3.36	4.87	5.05	.78	1.00	.014	"
237	5-9	.29	.65	1.30	3.22	3.76	4.76	.80	1.02	.012	"
238	6-10	.24	.67	1.41	2.80	4.40	5.55	.75	-	.009	"
239	7-11	.16	1.08	1.65	3.08	-	5.61	.82	.99	.010	"
240	8-12	.30	1.39	1.40	2.14	3.82	4.74	.81	1.00	.009	"
241	9-1	.25	.114	1.21	2.48	3.52	4.26	.81	1.02	.003	"
242	10-2	.25	.52	1.30	2.82	4.32	4.45	.81	0.96	.007	"
243	11-3	.19	.48	1.53	2.24	3.73	4.74	.76	1.08	.007	"
244[6]	12-4	.15	.76	1.07	2.48	3.78	4.98	.74	1.09	.008	"
245[6]	1-5	.13	.15	1.05	2.48	3.60	6.45	.55	1.04	.010	"
246	2-6	.13	-	-	-	-	6.50	.50	1.00	.008	"
247	3-7	.51	.50	2.19	2.86	5.04	6.84	.50	0.98	.014	"
248	4-8	.89	.99	1.59	3.02	4.88	6.78	.51	1.04	.003	"

Table A-1, Cont'd

Complete Data of Resin-in-Pulp Tests
Part II, Elution

Cycle No.	Cells on Elution	Assay[1] 1	2	3	4	5	El. Comp	Eluate Volume	Wash Vol	Wash Assay	Time Elution
249	5-9	.43	1.17	2.06	2.51	4.68	6.50	.52	1.06	-	30
250	6-10	.24	.84	2.09	4.66	4.0	6.55	.535	1.03	.014	"
251	7-11	.25	.97	1.88	2.98	3.92	6.43	.51	1.06	.018	"
252	8-12	.42	1.12	2.00	3.56	4.96	6.76	.52	1.00	.02	"
253	9-1	.21	1.17	1.91	2.74	4.48	5.76	.50	.98	.017	"
254	10-2	.51	.96	2.14	2.94	4.64	5.74	.51	1.04	.015	"
255	11-3	.43	1.08	3.23	3.46	4.80	5.80	.52	1.12	.015	"
256	12-4	.40	1.90	2.38	3.36	5.48	6.40	.52	1.10	.022	"
257	1-5	.36	1.62	2.21	3.82	4.80	6.65	.50	1.10	.029	"
258	2-6	.71	1.28	2.04	3.24	4.64	7.10	.525	1.03	.023	"
259	3-7	.62	1.38	2.55	3.12	5.24	7.20	.50	-	.024	"
260	4-8	.39	1.10	2.81	4.16	5.80	6 50	.52	-	.012	"
261	5-9	.62	2.13	2.74	4.96	6.10	7.20	.50	1.04	.034	"
262	6-10	.84	1.98	1.98	3.78	4.80	7.15	.63	1.05	.020	"
263	7-11	.44	-	-	-	5.92	7.15	.50	1.04	.029	"
264	8-12	1.17				5.52	7.15	.50	1.01	.070	"
265	9-1	.54				5.92	6.85	.50	1.00	.002	"
266	10-2	.48				5.24	6.50	.50	1.02	.085	"
267	11-3	.65				5.40	6.95	.53	1.04	.092	"
268	12-4	.67				5.92	6.95	.52	1.05	.036	"
269	1-5	.52				4.84	7.10	.52	.92	.032	"
270	2-6	.89				5.60	7.30	.52	1.01	.045	"
271	3-7	.68				5.68	6.85	.50	1.04	.042	"
272	4-8	.98				6.28	7.15	.52	1.04	.047	"
273	5-9	.97				5.36	7.70	.51	1.04	.039	"
274[2]	6-10	.70				4.56	6.90	.54			"
275	7-11	.54				6.04	7.90	.49			"
276	8-12	.24				6.48	7.65	.51			"
277	9-1	.18				6.20	8.45	.50			"
278	10-2	.13				5.64	7.30	.52			"
279	11-3	.29				5.68	7.55	.44			"

Table A-1, Cont'd

Complete Data of Resin-in-Pulp Tests
Part II, Elution

Cycle No.	Cells on Elution	Assay[1] 1	2	3	4	5	El. Comp	Eluate Volume	Wash Vol	Wash Assay	Time Elution
280	12-4	.22				6.32	8.00	.51			"
281	1-5	-				5.92	7.00	.49			"
282	2-6	-				6.48	6.85	.51			"
283	3-7	.45				5.12	7.25	.50			"
284	4-8	.16				5.56	7.40	.52			"
285	5-9	.33				6.56	7.90	.52			"
286	6-10	.22				5.56	6.75	.55			"
287	7-11	.27				5.76	7.87	.51			"
288	8-12	.23				5.64	7.50	.51			"
289	9-1	.31				5.36	7.10	.50			"
290	10-2	.22				5.44	7.40	.50			"
291	11-3	.19				5.76	7.00	.52			"
292	12-4	.18				6.28	7.15	.52			"
293	1-5	.15				6.88	7.13	.52			"
294	2-6	.23				6.52	7.45	.53			"
295	3-7	.25				6.25	7.38	.53			"
296	4-8	.25				5.92	7.75	.51			"
297	5-9	.12				6.44	7.15	.55			"
298	6-10	.51				6.98	7.18	.55			"
299	7-11	.35				6.34	7.53	.51			"
300	8-12	.27				6.20	6.80	.51			"
301	9-1	.24				5.80	6.80	.52			"
302	10-2	.28				6.23	6.56	.54			"
303	11-3	.22				6.33	6.72	.50			"
304	12-4	.27				6.48	6.55	.53			"
305	1-5	.31				6.70	6.96	.53			"
306	2-6	.43				6.65	6.84	.55			"
307	3-7	.32				6.72	7.30	.49			"
308[8]	4-8	.29				6.23	6.60	.52			"

Footnotes

1/ Cell numbers indicate position in adsorption or elution train. Actual cells involved are shown in Column 2. All assays are in g U_3O_8/L.

2/ A steady increase in the uranium concentration of the composite effluent up to this point indicated that more uranium was being passed over the resin than could be adsorbed. In order to bring the system into balance, in cycle 22 the two end cells (4 & 5 in the string) were eluted batchwise, and in cycle 23 fresh resin was substituted for the partially loaded resin in the last 3 cells of the adsorption train.

3/ Cycles 1 through 37 were run with artificial solution. At the end of cycle 37 the adsorption cells were drained and pulp flow was started. For cycle 38 no barren pulp was produced because all pulp added was required to fill system.

4/ At the end of this adsorption cycle the elution procedure was changed to that described as procedure 2 on page 25 of the text.

5/ Caustic elution started with cycle 181. At the end of the elution cycle, the completely eluted resin in the first cell of the elution train was removed, and treated with caustic as described in the test on pate 29. The volume of the regenerated resin was measured and the resin returned to the system. The average resin volume per cell as determined at this time was 137 ml in comparison with the 150 ml originally present.

6/ At the end of this adsorption cycle the elution procedure was changed to that described as procedure 3 on page 26 of the test.

7/ At the end of the adsorption cycle, the elution procedure was changed to that described as procedure 4 on page 28 of the text.

8/ At the end of the test, the volume of resin in each cell was measured and averaged 125 ml.

Table A-2

Summary Table Reagent Consumption, Loading and Precipitate Grade Data for RIP Tests

Cycle No.	Eluate Vol L	Eluate Vol RV	Ppt Wt, g	Ppt Grade, %	Calc Load, g Eluate	Calc Load, g Ppt	Reagents NH_4Cl, g	Reagents g Cl^-	Reagents HCl, ml	Reagents g Cl^-	g Cl^-/ml resin
6-14 1/	10.84	8.3	95.0	79.5	55.6	57.8	135	(89.5)	155	(66.6)	120
15-24	9.16	6.3	81.0	78.1	49.2	43.7	74.5	(49.4)	125	(53.7)	71
25-35	19.12	12.0	102.0	78.5	43.5	50.2	45	(29.9)	190	(81.7)	70
36-47 2/	11.78	6.8	79.0	70.8	34.8	35.0			200	(86.0)	49
48-60	13.73	7.3	54.0	87.8	28.3	25.2	60	(39.8)	135	(58.0)	52
61-72	12.45	7.2	61.0	82.6	30.4	29.0			150	(64.5)	37
73-85	13.32	7.1	71.0	83.1	31.6	31.3			185	(79.5)	42
86-96	11.41	7.2	58.0	84.0	30.8	30.6			113	(48.6)	30
97-108	12.06	6.9	58.0	80.0	30.9	26.7			160	(68.8)	40
109-120	12.11	7.0	56.7	84.1	29.6	27.4			180	(77.5)	45
121-134	14.13	7.0	65.0	82.0	27.2	26.3			179	(77.0)	38
135-144	10.38	7.1	54.2	73.5	29.2	27.5			150	(64.5)	44
145-158	15.02	7.4	73.0	83.0	28.8	29.8			194	(83.5)	41
159-181	22.61	6.8	124.0	71.5	28.2	26.6			213	(91.6)	27
182-193	9.95	5.7	72.8	73.7	29.6	30.8			100	(43.0)	25
194-205 3/	9.81	6.0	57.8	87.5	29.5	30.8			91	(39.2)	24
206-218	10.70	6.0	62.2	78.5	29.9	27.4	15	(10.0)	120	(51.6)	35
219-230	8.61	5.2	60.0	89.0	27.8	32.4	45	(29.8)	93	(40.0)	42
231-242	9.36	5.7	54.0	74.0	28.0	24.3	35.8	(23.8)	124	(53.3)	47
243-254	6.66	4.1	53.0	77.3	24.6	24.9					
255-267	6.75	3.8	63.0	62.5	25.8	22.1	17.4	(11.5)	90.5	(38.9)	28
268-279	6.09	3.7	49.0	85.5	27.3	25.4			107	(46.0)	28
280-291	6.14	3.7	62.0	69.8	27.2	30.2	(20.0)		102	(43.9)	39
292-308	8.91	3.8	72.0	70.8	26.4	21.9					

Average loading = 29 g U_3O_8/L WSR
Average reagent consumption = 1.2 lbs HCl + 0.2 lb NH_4Cl/lb U_3O_8 recovered

1/ 145 ml resin/cell
2/ 1 cycle of eluate discarded
3/ 137 ml resin/cell

Table A-3

Vitro Column Data

Cycle No.	Vol, L	Assay, g/L	% Adsorption	Col Vol, ml	Loading, g/L	Remarks
1	4.0	.0001	100			Head = 1.00 U_3O_8, 2.54 V_2O_5,
2	3.5	.003	99.7	475	58.1	3.07 Fe^{+++}, 0.68 Fe^{++}, 0.33
3	3.5	.021	97.9	490	57.7	P_2O_5, 0.0022 Mo, pH = 1.3,
4	3.0	.035	96.5	490	63.8	3 min ex. ret. time and 9 min
5	3.0	.042	95.8	500	59.2	el. ret. time 0.9M NH_4Cl +
6	3.0	.038	96.2	490	59.4	0.1M HCl fresh eluate for all
7	2.5	.014	98.6	490	59.2	cycles 50 ml IRA-400 resin/
8	2.5	.0019	99.8	570	56.7	column.
9	2.5	.0003	100	500	61.2	
10	2.5	.0001	100	495	59.8	
11	2.5	.0006	99.9	495	56.4	
12	3.0	.0002	100	500	55.0	
13	3.0	.0018	99.8	495	59.1	
14	3.0	.0021	99.8	500	59.2	
15	3.0	.014	98.6	500	59.2	
16	3.0	.027	97.3	500	60.0	
17	2.75	.022	97.8	510	59.3	
18	2.75	.023	97.7	500	59.2	
19	2.75	.030	97.0	500	60.7	
20	2.75	.035	96.5	500	59.2	
21	2.6	.029	97.1	500	58.3	
22	2.6	.028	97.2	510	59.9	
23	2.6	0.14	98.6	515	58.1	
24	2.6	.015	98.5	515	59.0	
25	2.6	.034	97.0	530	59.6	New Head = 1.13 U_3O_8
26	2.6	.060	94.7	510	57.7	
27	2.6	.083	92.7	510	57.8	
28	2.5	.151	86.6	510	58.5	
29	2.5	.061	94.6	525	59.1	
30	2.5	.064	94.3	500	57.8	
31	1.95	.001	99.9	600	60.0	New Head = 1.18 U_3O_8, 0.66 V_2O_5,
32	1.95	.001	99.9	590	60.6	1.28 Fe^{++}, 0.70 P_2O_5, 0.18 Mo,
33	1.95	.024	98.0	595	56.0	pH = 1.3
34	1.95	.116	90.2	580	46.4	0.1 spot at 500 ml
35	1.95	.232	80.3	620	38.8	
36	1.95	.371	68.6	630	38.2	
37	1.95	.41	65.2	645	39.1	0.1 spot at 555 ml
38	1.00	.26	88.0	670	29.2	
39	1.00	.28	76.3	850	24.9	
40	1.00	.35	70.4	740	19.1	
41	1.00	.33	72.0	730	16.5	
42	1.00	.41	65.2	810	15.7	0.1 spot at 720 ml
43	1.00	.49	58.5	720	14.6	
44	1.00	.0004	100	830	15.2	.1 spot at 740 ml, start caustic
45	2.0	.0005	100	760	16.8	cleanup
46	2.5	.015	98.7	840	40.3	.1 spot at 750 ml, 9 min el. ret.
47	2.5	.119	89.9	625	42.4	time, 0.1 spot at 520 ml

Table A-3. Continued

Vitro Column Data

Cycle No.	Effluent Vol, L	Effluent Assay, g/L	% Adsorption	Col Vol, ml	Loading, g/L	Remarks
48	2.5	.243	79.4	660	54.2	0.1 spot at 570 ml
49	2.5	.379	67.9	710	46.8	
50	2.5	.171	60.8	670	44.2	.1 spot at 580 ml
51	2.5	.0005	99.9			New Head = 0.67 U_3O_8, 0.011
52	1.2	.0001	100	340	36.7	Mo, Load fresh resin in all
53	1.2	.0007	99.9	340	38.6	columns, 50 ml XE-75/column
54	1.2	.0007	99.9	340	33.4	0.1 spot at 250 ml
55	1.2	.0007	99.9	345	32.7	
56	1.2	.0006	99.9	330	31.5	
57	1.2	.0007	99.9	320	29.6	
58	1.2	.0008	99.9	340	32.5	
59	1.2	.0015	99.8	340	30.4	
60	1.2	.0010	99.8	340	29.6	0.1 spot at 250 ml
61	1.2	.0015	99.8	335	25.8	
62	1.2	.0009	99.9	330	26.0	
63	1.2	.0008	99.9	340	24.2	
64	1.2	.0010	99.8	355	18.1	
65	1.2	.0003	100	390	30.1	
66	1.5	.0010	99.8	350	30.3	0.1 spot at 250 ml
67	1.5	.001	99.8	305	28.5	
68	1.5	.003	99.6	350	30.8	
69	1.5	.005	99.3	330	31.9	
70	1.5	.008	98.8	320	31.4	
71	1.5	.025	96.3	335	31.4	
72	1.5	.051	92.4	335	31.4	0.1 spot at 250 ml
73	1.5	.055	91.8	335	32.4	
74	1.25	.059	91.2	360	31.9	
75	1.25	.027	96.0	350	33.9	
76	1.25	.015	97.8	355	30.7	
77	1.25	.021	96.9	340	30.4	
78	1.25	.017	97.5	335	30.0	0.1 spot at 250 ml
79	1.25	.013	98.1	340	26.8	
80	1.25	.017	97.5	350	29.4	
81	1.25	.028	95.8	340	30.1	
82	1.25	.019	97.2	350	28.6	
83	1.25	.023	96.6	340	31.1	
84	2.0	.016	97.9	340	30.7	New Head = 0.75 g/L U_3O_8, 0.06
85	2.0	.033	95.6	340	27.4	Mo, 0.83 V_2O_5, 0.4 P_2O_5, 1.6
86	2.0	.061	91.9	355	27.3	Fe^{+++}, 0.3 Fe^{++}, pH = 1.3
87	2.0	.074	90.1	350	26.4	
88	2.0	.071	90.5	340	24.7	
89	2.0	.083	88.9	360	27.7	0.1 spot at 250 ml
90	2.0	.008	98.9	460	26.2	Start caustic cleanup
91	2.0	.005	99.3	350	24.5	
92	2.0	.0001	100	345	34.4	
93	2.0	.0004	99.9	325	30.6	
94	2.0	.0002	100	335	33.8	

Table A-3, Continued

Vitro Column Data

Cycle No.	Vol, L	Assay, g/L	% Adsorption	Col Vol, ml	Loading, g/L	Remarks
95	2.1	.0002	100	360	32.5	
96	2.1	.0002	100	360	30.6	
97	2.2	.001	99.9	340	33.0	
98	2.2	.001	99.9	330	31.6	
99	2.2	.0003	100	355	27.2	
100	2.7	.0002	100	370	30.8	New Head = 0.59 U_3O_8, 0.041 Mo
101	2.7	.0002	100	370	29.6	
102	2.7	.0009	99.9	375	30.6	
103	2.7	.0001	100	325	29.7	
104	2.7	.0004	99.9	350	28.3	
105	2.7	.0004	99.9	395	30.6	
106	2.7	.0005	99.9	340	27.2	
107	2.7	.0002	100	370	26.3	
108	2.7	.003	99.5	335	30.2	0.1 spot at 240 ml
109	2.7	.0003	99.9	330	27.5	
110	2.7	.002	99.7	350	28.7	
111	2.7	.0007	99.9	345	30.4	
112	2.7	.0004	99.9	325	28.4	
113	2.7	.0007	99.9	340	32.0	
114	2.7	.0004	99.9	435	31.5	
115	2.7	.0002	100	330	32.2	
116	2.7	.0002	100	375	32.9	
117	2.7	.0002	100	350	31.2	
118	2.7	.0003	99.9	370	31.3	
119	2.7	.001	99.8	370	33.4	
120	2.7	.0004	99.9	395	32.2	
121	2.7	.0003	99.9	365	30.8	
122	2.7	.0005	99.9	400	33.2	
123	2.7	.002	99.7	370	32.4	
124	2.7	.0009	99.9	365	33.8	
125	2.7	.0005	99.9	350	--	
126	2.7	.0004	99.9	350	31.3	0.1 spot at 250 ml
127	2.7	.0005	99.9	335	30.4	
128	2.7	.0006	99.9	405	27.1	
129	2.7	.0006	99.9	335	29.5	
130	2.7	.0004	99.9	345	29.4	
131	2.7	.0004	99.9	355	29.5	
132	2.7	.0006	99.9	360	29.6	
133	2.7	.001	99.8	355	30.0	
134	2.7	.0006	99.9	370	29.6	
135	2.7	.0006	99.9	340	29.9	
136	2.7	.0003	99.9	345	31.0	
137	2.7	.0007	99.9	365	29.1	
138	2.7	.0007	99.9	350	3.06	
139	2.7	.0004	99.9	380	30.4	
140	2.7	.001	99.8	340	26.7	
141	2.7	.001	99.8	340	29.2	

Table A-3, Continued

Vitro Column Data

Cycle No.	Vol, L	Assay, g/L	% Adsorption	Col Vol, ml	Loading, g/L	Remarks
142	2.7	.001	99.8	340	31.7	
143	2.7	.001	99.8	370	-	
144	2.7	.002	99.7	330	29.6	
145	2.7	.005	99.2	350	34.4	
146	2.7	.004	99.3	350	30.1	
147	2.7	.008	98.7	375	30.2	
148	2.7	.006	99.0	390	29.3	
149	2.7	.010	98.3	330	28.6	
150	2.7	.001	99.8	370	31.6	Start clean up
151	2.7	.0002	100	340	34.7	
152	2.7	.0001	100	455	35.7	
153	2.7	.0005	99.9	360	35.4	
154	2.7	-	-	365	36.9	
155	2.7	.0002	100	370	34.2	
156	2.7	.0004	99.9	375	35.3	
157	2.7	.0006	99.9	350	33.1	
158	2.7	.0001	100	400	31.2	0.1 spot at 250 ml
159	2.7	.0003	99.9	345	29.6	
160	2.7	.0003	99.9	400	-	
161	2.7	.001	99.8	300	26.0	
162	2.7	.0006	99.9	340	29.4	New head=0.58 U_3O_8, 0.038 Mo
163	2.7	.003	99.5	440	27.0	
164	2.7	.0007	99.9	330	26.9	
165	2.7	.0005	99.9	350	27.7	
166	2.7	.004	99.3	420	30.2	
167	2.7	.0009	99.8	330	33.6	
168	2.7	.0003	99.9	340	31.6	
169	2.7	.0005	99.9	385	33.0	
170	2.7	.0006	99.9	330	32.6	
171	2.7	.002	100	32.8		