UNCLASSIFIED

UNCLASSIFIED

OK

OAK RIDGE NATIONAL LABORATORY

Operated By

UNION CARBIDE NUCLEAR COMPANY

UCC

POST OFFICE BOX P
OAK RIDGE, TENNESSEE

L

ORNL
CENTRAL FILES NUMBERCF-55-10-66
UNCLASSIFIED

DATE: October 20, 1955

SUBJECT: Raw Materials Economic Studies: A Preliminary Estimate of the Cost of Uranium Recovery Using Dalphex Clarified Leach Liquor Process

TO: H. M. McLeod, Jr.

FROM: B. B. Klima, R. R. Wiethaup, R. H. Guymon

LEGAL NOTICE

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

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

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

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

NOTICE

Photostat Price \$ 3.30

Microfilm Price \$ 2.40

Available from the
Office of Technical Services
Department of Commerce
Washington 25, D. C.

UNCLASSIFIED

1 2501

472-1

DISCLAIMER

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

DISCLAIMER

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

RAW MATERIALS ECONOMIC STUDIES:A PRELIMINARY ESTIMATE OF THE COST OF URANIUM RECOVERYUSING DALPHEX CLARIFIED LEACH LIQUOR PROCESS

B. B. Klima, R. R. Wiethaup, R. H. Guymon

This report presents the cost of recovery of uranium from a clarified sulfuric acid leach liquor by solvent extraction using dialkylphosphoric acid reagent (DALPHEX Process). The estimate is based upon the results of laboratory work through September, 1955.

The process is shown in Figs. 1 and 2. Briefly, it consists of extracting the uranium with di(2-ethylhexyl)phosphoric acid (D2EHPA) dissolved in kerosene containing 30 g/l of tributyl phosphate (TBP) in a four-unit mixer-settler and stripping it from the loaded organic with aqueous sodium carbonate in a two-unit mixer-settler. Extraction of iron is prevented by reducing it to the ferrous state with powdered iron in the leach operation. The loaded strip solution is neutralized with sulfuric acid, heated to remove carbon dioxide, and ammonium hydroxide is added to precipitate the uranium. The process costs end with the filtered and washed cake ready for the drying or calcining operation.

At a production rate of 1122.7 lbs U_3O_8 per day (a mill capacity of 200 tons of ore per day assaying 0.3% U_3O_8) it is estimated that the solvent extraction facility would cost \$189,888 and that the total of direct operating costs plus amortization would be \$0.471 per pound of U_3O_8 , as shown in Tables 1 and 2. The cost of chemicals is shown in Table 3, and the installed cost of process equipment in Table 4. The criteria are summarized in Table 5.

The above costs may be compared with those of alternative processes as shown in Fig. 3 and as described in ORNL-1927. Reports in which such costs are presented are listed in the Bibliography.

Applicable portions of "Suggested Procedure for Economic Evaluations for Uranium Recovery Plants," Grand Junction Operations Office, AEC, have been employed.

UNCLASSIFIED

472-2

UNCLASSIFIED

UNCLASSIFIED

FIGURE 1 - PROCESS AND EQUIPMENT FLOW DIAGRAM

872-3

FIGURE 2 - MATERIALS FLOW DIAGRAM

TABLE 1. COST OF DALPHEX CLARIFIED LIQUOR PROCESS

	Cost Per Day	Cost Per Pound of U ₃ O ₈
Labor		
Operating <u>1/</u>	\$162.00	\$0.144
Maintenance <u>2/</u>	21.10	0.019
Supplies		
Operating <u>3/</u>	202.11	0.180
Maintenance <u>4/</u>	26.37	0.024
Utilities		
Electricity	7.21	0.006
Steam	<u>4.85</u>	<u>0.004</u>
Total Operating Cost	\$423.64	\$0.377
Amortization <u>5/</u>	<u>105.49</u>	<u>0.094</u>
Total	\$529.13	\$0.471

1/ Three men per shift.

2/ Four percent of Total Construction Cost per 360-day year (see Table 2).

3/ See Table 3.

4/ Five percent of Total Construction Cost per 360-day year (see Table 2).

5/ 20% of Total Construction Cost per 360-day year (see Table 2).

UNCLASSIFIED

472-5

TABLE 2. COST OF DALPHEX CLARIFIED LIQUOR
PROCESS FACILITY

A.	Cost of installed process equipment <u>1/</u>	\$ 71,500
B.	Other Direct Costs	
	Process piping (30% of A)	21,450
	Instrumentation (3% of A)	2,145
	Electrical wiring <u>2/</u>	3,565
	Building (68,640 cu ft) <u>3/</u>	39,000
	Footings and foundations (5% of A)	3,575
	Painting and scaffolding (2% of A)	<u>1,430</u>
C.	Total Direct Costs	\$142,665
D.	Engineering and field expense (10% of C)	14,267
E.	Contingency [10% of (C+D)]	15,693
F.	Contractor's fee and overhead [10% of (C+D+E)]	<u>17,263</u>
G.	Total Construction Cost	\$189,888

1/ Includes material, labor, and freight (see Table 4).

2/ Includes lighting, equipment, and instrumentation.

3/ Does not include lighting or sanitary facilities.

TABLE 3. COST OF OPERATING SUPPLIES
DALPHEX CLARIFIED LIQUOR PROCESS

Chemical	Daily Usage	Unit Cost <u>1/</u>	Cost per Day	Cost per lb U ₃ O ₈
Kerosene	26 gal	\$0.14	\$ 3.64	\$0.003
Tributyl Phosphate (TBP)	31.4 lbs	0.53	16.64	0.015
Di(2-ethylhexyl)phosphoric acid (D2EHPA)	12.8 lbs	0.6146	7.87	0.007
Iron	1140 lbs	0.0655	74.67	0.066
Sodium Carbonate	2424 lbs	0.0225	54.54	0.049
Sulfuric Acid (98%)	1764 lbs	0.0150	26.46	0.024
Ammonia (100%)	318 lbs	0.0575	18.29	0.016
Total			\$202.11	\$0.180

1/ Delivered in Grand Junction, Colorado.

UNCLASSIFIED

UNCLASSIFIED

472-7

TABLE 4. INSTALLED PROCESS EQUIPMENT COSTS

DALPHEX CLARIFIED LIQUOR PROCESS

Item No.* No. Req'd	Description	Installed Cost
T-1 2	Leach Liquor Feed Storage Tank, 100,000 gal, wood, 25 hp agitator	\$24,390
T-2 4	Extractor Mixer, 211 gal, Haveg 41, 1 hp agitator	5,960
T-3 4	Extractor Settler, 189 gal, Haveg 41	3,240
T-4 1	Entrainment Separator, 559 gal, Haveg 41	1,145
T-5 1	Organic Storage, 1250 gal, plastic lined steel	1,120
T-6 1	Kerosene Storage, 1500 gal steel	440
T-7 1	Organic Make-up, 100 gal steel, 1/2 hp agitator	570
T-8 1	Organic Extract Head Tank, 159 gal, Haveg 41	680
T-9 2	Stripping Mixer, 258 gal, Haveg 60, 1 hp agitator	3,130
T-10 2	Stripping Settler, 258 gal, Haveg 60	1,680
T-11 2	Strip Solution Make-Up Tank, 1269 gal, steel, 2 hp agitator	2,030
T-12 3	Precipitation Tank, 1248 gal, wood, 2 hp agitator	3,285
T-13 1	Filtrate Tank, 2278 gal, wood	630

*Includes spares where necessary.

TABLE 4 (continued)

Item No.	No.* Req'd	Description	Installed Cost
P-20	1	Leach Liquor Feed Pump, 75 gpm, stainless steel	\$ 930
P-21	2	Raffinate Pump, 75 gpm, stainless steel	1,860
P-22	5	Extractor Interstage Pump, 75 gpm, stainless steel	4,650
P-23	2	Organic Feed Pump, 25 gpm, stainless steel	1,600
P-24	1	Kerosene Transfer Pump, 20 gpm, mild steel	470
P-25	1	Organic Make-up Pump, 20 gpm, mild steel	470
P-26	2	Organic Extract Pump, 25 gpm, stainless steel	1,600
P-27	2	Strip Solution Feed Pump, 5 gpm, Hastelloy	1,070
P-28	1	Filter Feed Pump, 30 gpm, rubber lined	950
P-29	1	Filtrate Pump, 30 gpm, rubber lined	950
P-30	2	Strip Interstage Pump, 5 gpm, Hastelloy	1,070
F-40	2	Filter Press, 480 sq ft, wood	7,580
Total			\$71,500

*Includes spares where necessary.

TABLE 5. CRITERIA, DALPHEX CLARIFIED LIQUOR PROCESS

General

Location of mill <u>1</u> /	Grand Junction, Colorado
Mill capacity <u>1</u> /	200 tons of ore per day
Ore assay <u>1</u> /	0.3% U_3O_8
Feed to extractor	Clarified leach liquor
U_3O_8 in clarified leach liquor	94.0% of U_3O_8 in the ore
Unaccountable loss of U_3O_8 <u>1</u> /	0.25% of U_3O_8 in leach liquor

Extraction

Extractant	di(2-ethylhexyl)phosphoric acid (D2EHPA)
Conc. of extractant	0.1 molar
Molecular wt of extractant	322
Diluent	30 gm/l tributyl phosphate (TBP) in kerosene
Loading of extract	5.90 g U_3O_8 per liter
Number of stages	4 countercurrent
Mixer: <u>3</u> /	
Type	baffled mixer
Residence time	2 minutes
Settler: <u>3</u> /	
Type	shallow tank
Aqueous holdup	1-3/4 minutes
Organic holdup	3 minutes

1/ AEC or section standard.2/ Laboratory.3/ Process testing.

UNCLASSIFIED

472-10

TABLE 5 (continued)

Extraction (continued)

U ₃ O ₈ in raffinate	0.003 g U ₃ O ₈ per liter of sol'n
U ₃ O ₈ in barren organic <u>2/</u>	0.012 g U ₃ O ₈ per liter

Stripping

Reagent	100 gm/l sodium carbonate
Theoretical requirement <u>2/</u>	3 moles CO ₃ /mole U plus 1/2 mole CO ₃ /mole excess D2EHPA
Usage <u>2/</u>	130% of theoretical
Conc. of U ₃ O ₈ in loaded strip sol'n <u>3/</u>	56.6 g U ₃ O ₈ per liter
Number of stages <u>2/</u>	two, countercurrent
Residence time in mixer <u>4/</u>	12 minutes
Residence time in settler <u>4/</u>	12 minutes
Impeller diameter	1/2 tank diameter
Impeller speed	350 rpm

Product Recovery

Amount of sulfuric acid	neutralize all CO ₃ ⁼ and acidify to pH of 1.5
Precipitant	ammonia (anhydrous)
Theoretical requirement	3 moles NH ₃ /mole U
Usage <u>3/</u>	150% of theoretical
Product grade	75% U ₃ O ₈
Filter cake	60% water
U ₃ O ₈ in filtrate	0.001 g U ₃ O ₈ per liter

4/ Assumed.UNCLASSIFIED

472.11

TABLE 5 (continued)Reduction 2/

Reducing agent	iron
Particle size	100 mesh
Theoretical requirement	0.5 moles Fe per mole Fe(III) reduced
Usage	125% of theoretical
Reaction time	30 minutes
Fe(III) in liquor	Twice conc. of U_3O_8
Degree of completion of reduction	80% of Fe(III) in liquor

Loss of Organic Materials

Entrainment in:

Raffinate	0.25 ml organic per liter aqueous
Loaded strip <u>4/</u>	0.025 vol%

Solubility 2/

D2EHPA in leach liquor	5 ppm
D2EHPA in loaded strip	75 ppm
TBP in leach liquor	30 ppm
TBP in loaded strip	40 ppm
Miscellaneous losses <u>4/</u>	100 gal per month

FIGURE 3. DIAGRAM SHOWING THE RELATIONSHIP BETWEEN COST ESTIMATES OF VARIOUS STEPS IN THE RECOVERY PROCESSES FOR SEVERAL METHODS OF URANIUM RECOVERY.

UNCLASSIFIED

BIBLIOGRAPHYESTIMATES MADE AS PART OF THE
RAW MATERIALS ECONOMIC STUDIES

1. B. B. Klima, W. T. Ward, R. R. Wiethaup, Abridged Estimate of the Cost of Uranium Extraction by the Resin-in-Pulp (R.I.P.) Process, ORNL CF-55-3-21, March 4, 1955.
2. B. B. Klima, W. T. Ward, R. R. Wiethaup, An Abridged Estimate of the Cost of Clarification, ORNL CF-55-3-59, March 10, 1955.
3. B. B. Klima, W. T. Ward, R. R. Wiethaup, An Abridged Estimate of the Cost of Sand Slime Separation, ORNL CF-55-3-71, March 14, 1955.
4. B. B. Klima, W. T. Ward, R. R. Wiethaup, Preliminary Estimate of the Cost of Uranium Extraction by Dow Sixty Percent Slurry Process, ORNL CF-55-3-104, March 18, 1955.
5. B. B. Klima, W. T. Ward, R. R. Wiethaup, A Preliminary Estimate of the Cost of Solvent Extraction Using Amine Reagent, ORNL CF-55-3-110, March 21, 1955.
6. B. B. Klima, W. T. Ward, R. R. Wiethaup, A Preliminary Estimate of the Cost of Drying or Calcining and Packaging of Product, ORNL CF-55-3-140, March 24, 1955.
7. B. B. Klima, W. T. Ward, R. R. Wiethaup, Preliminary Estimate of the Cost of Uranium Extraction from Sixty Percent Slurry Using D2EHPA Reagent, ORNL CF-55-3-193, March 31, 1955.
8. H. M. McLeod, et al., Scope of the Raw Materials Cost Evaluation Studies, ORNL-1927, September 8, 1955.
9. H. M. McLeod, et al., Cost of Uranium Recovery by the Amine Extraction Process, ORNL-1949, September 8, 1955.
10. B. B. Klima, R. R. Wiethaup, A Preliminary Estimate of the Cost of Amine Extraction - Sodium Chloride Strip, ORNL CF-55-9-55, September 15, 1955.

UNCLASSIFIED

472-14

11. B. B. Klima, R. R. Wiethaup, A Preliminary Estimate of the Cost of Uranium Recovery from a Slime Slurry.
I. DEPA-Capryl Alcohol, ORNL CF-55-9-85, September 21, 1955.
12. B. B. Klima, R. R. Wiethaup, A Preliminary Estimate of the Cost of Uranium Recovery from a Slime Slurry.
II. DEPA - TBP, ORNL CF-55-9-127, September 28, 1955.
13. B. B. Klima, R. R. Wiethaup, A Preliminary Estimate of the Cost of Uranium Recovery from a 50% Slurry:
D2EHPA - TBP Reagent, ORNL CF-55-10-46, October 18, 1955.

THIS PAGE
WAS INTENTIONALLY
LEFT BLANK