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RECORD CENT FILE

December 31, 1948

Atomic Energy Commission
Hanford Operations Office
Richland, Washington

Attention: Mr. R. C. Hageman
Chief, Operations Division

Gentlemen:

METAL RECOVERY PROCESSES SURVEY

Those processes which will yield decontaminated uranium by means of solvent extraction or uranyl ammonium phosphate-fluorination are currently being studied by the General Electric Company in various combinations, in order to determine the most attractive processes from the standpoint of construction cost, time to begin operation, operating cost, engineering design, and process chemistry.

We submit for your information the attached diagram and tables which indicate our present approach toward obtaining the information we need for basing sound recommendations. The present summary is representative of our progress to date. Additional information is expected to result in some revisions.

By March 1, 1949, we expect to have completed the compilation and survey of the data, including estimated construction costs.

In the next few weeks, our activities will be chiefly concerned with the development of construction costs.

The following are the cases or proposals we are studying and comprise the combinations of solvent extraction, bismuth phosphate ($BiPO_4$ = present process) and uranyl ammonium phosphate processes to yield uranium hexafluoride as the end product:

Proposal or Case No.	Process or Combination	Plants made Obsolete	Future Plants in Operation
1.	Bi PO_4 plus uranyl ammonium phosphate (U.A.P.) for two year old waste	None	Bi PO_4 plus U.A.P. (at less than maximum capacity)
2.	Bi PO_4 plus Solvent Extraction (S.E.) for two year old waste	None	Bi PO_4 plus S.E. (at less than maximum capacity)
3.	Bi PO_4 plus U.A.P. for aged and current waste	None	Same as 1.
4.	Bi PO_4 plus S.E. for aged and current waste	None	Same as 2.
5.	Redox plus U.A.P. for old waste	Bi PO_4 and U.A.P.	Redox
6.	Redox plus S.E. for old waste	Bi PO_4 and S.E.	Redox
7.	Redox for old and current metal waste	Bi PO_4	Redox at less than maximum capacity
8.	Solvent extraction to separate Pu from U; Pu processed as at present via Bi PO_4. U decontaminated via S.E. plus separate S.E. plant for aged waste	S.E. for aged waste	S.E. for separating Pu from U and decontamination of U; Bi PO_4 for Pu decontamination
9.	Solvent extraction to separate Pu from U in current waste; Pu decontaminated via Bi PO_4, U decontaminated via solvent extraction	None	S.E. for separating Pu from U and decontaminating U operated at less than maximum capacity plus Bi PO_4 for Pu

We recognize that work has been in progress on other processes for metal recovery — for example, a straight fluorination process and the electrolytic process. It is our opinion, however, that the U.A.P. and solvent extraction processes are further developed and that design work on either could proceed on the basis of available information. Data may be available shortly on other processes which may lead to the decision to consider these processes and combinations also.

The essential bases we are using in this study are as follows:

1. The nine proposals above are being compared at capacities which will yield four metric tons of decontaminated metal per day from stored and current waste, until the stored waste is totally recovered or reaches the constant inventory as required by Proposals 1 and 2.

2. All proposals are to yield the hexafluoride as the end product. It is recognized that all steps required to yield this product need not necessarily be conducted at this site, except in those cases wherein fluorination is a required step for decontamination. (Proposals 1, 3, and 5) Unit costs and capacities of other manufacturing locations will be used where applicable in our study.

3. Consideration is not being given at this time to the details of process revisions which may also yield recovered plutonium from metal wastes. For Proposals 7 and 9, however, a dotted line in the diagram indicates the path of any such desired recovery.

4. All solvent extraction processes are expected to yield decontaminated uranium nitrate solution.

5. For solvent extraction processes, waste metal preparation for feed will be by the U.A.P. - caustic metathesis process.

6. The sluicing method as proposed by both Carbide and Kellex will be used for removal of waste from storage tanks. Kellex construction cost figures for this step will be used where applicable.

7. The U.A.P. processes will be based on two U.A.P. precipitations. Carbide has provided data to show the satisfactory decontamination obtained by this departure from the proposal of their "Status Report".

8. Solvent extraction processing will vary as follows:

   a. For processes in which column feed is prepared directly from current metal (Proposals 5, 6, 7, 8, 9), three uranium cycles will be used.

   b. For processes in which U.A.P. - Metathesis is used to prepare feed from Bi PO_4 process current and aged waste (Proposals 2, 4, 6, 7, and 9), two uranium cycles will be used.

   c. For Redox processes, the third cycle waste will be "cribbed".

   d. For processes utilizing U.A.P. - Metathesis, second cycle wastes in the solvent extraction step will be "cribbed".

   We recognize that "cribbing" of any activity may have to be abandoned. Such a policy will, however, apply to any present or future process considerations.

9. All preparation of the tetrafluoride is to be done via dry methods. Carbide has shown satisfactory decontamination by this means as a step in their U.A.P. processes yielding the hexafluoride as the final product.

10. A 99+ % yield is assumed for all processes.

11. For neutralized process wastes which can be concentrated, consideration will be given to concentrating in the plant buildings to a crystallization temperature of 20° C. Further concentration may be considered at the point of final storage.

12. Existing spare or idle facilities (U - Canyon) will be used wherever economically possible in the proposed processes.

13. Construction cost estimates will be made, utilizing in the best possible manner cost data now available on presently proposed construction (Redox). It may also be necessary to bring the cost of existing types of construction to present-day figures in some cases, for the comparison.

14. Value of existing facilities which may be utilized will not be included in construction cost figures. Cost of adaptation will, of course, be added into construction costs.

15. For those proposals in which a plant is built separately for old waste recovery and which is obsolete when the recovery program is completed, we propose a single plant to process waste from both areas (200-E and 200-W).

16. For permanent operations, complete facilities will be provided in both areas. This requirement may be limited to processing of active material; economics should favor centralized processing of decontaminated products.

17. The degree of overdesign incorporated in our study will be essentially the same as for the present Redox design. This includes spare cells and a 20% process capacity safety factor.

18. Remote control and remote maintenance will be proposed in all processing wherein shielding and contamination are involved.

19. The operating year is to be 365 days.

20. Chemical cost figures have been obtained from the Purchasing Division. Fluorine was taken at $0.50/lb, the figure used by Carbide in its "Status Report".

The attached Block Flow Diagram (H-2-1520) shows, via strip comparison, the essential features of each proposal, together with indicated obsolescence.

The "Comparison of Daily Chemical Costs" is derived from the companion chart, "Comparison of Daily Chemical Consumption and Costs - Unit Processes", which subdivides the consumption into the "units" of each proposal, such as U.A.P. - Metathesis, Solvent Extraction, Fluorination, etc. Costs are shown for the period of metal recovery, as well as on an annual basis after the recovery program has been completed.

The "Comparison of Storage of Neutralized Stored Wastes" shows the cumulative total gallons of waste to be stored over the period of aged metal waste recovery and also the annual storage after the recovery program has been completed. Costs of storage facilities at forty cents per gallon are also shown.

Very truly yours,

R H Beaton

R. H. Beaton, Head
Separations Technology Division

RHB/jw

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COMPARISON OF DAILY CHEMICAL CONSUMPTIONS AND COSTS

UNIT PROCESSES

BASES: 1) All unit processes are compared at a production rate of one metric ton of uranium (TU) per day.
2) All unit processes leading to decontaminated uranium contain costs of HF and F_2 required for conversion to UF_6. UAP costs are for dry hydrofluorination process. Others include the steichiometric quantity of HF required for UF_4 plus 10% excess.
3) Unit costs were obtained from latest plant cost figures where available, otherwise from vendor's quotations, late price listings plus freight costs, or estimates.

Unit Cost	Material	UAP 2 yr. Waste		UAP Current Waste		BiPO4 From Metal		BiPO4 After 5%		Metathesis, 2 yr. Waste		Metathesis, Current Waste		Redox		Solvent Extraction from Metal		Solvent Extraction from Metathesis	
		Lb/TU	Cost a	Lb/TU	Cost b	Lb/TU	Cost c	Lb/TU	Cost d	Lb/TU	Cost e	Lb/TU	Cost f	Lb/TU	Cost g	Lb/TU	Cost h	Lb/TU	Cost i
3.76	HNO_3	13,924	523.54	4,812.5	180.95	6,977	262.34	3,164	118.97	11,077	416.50	1,966	73.92	4,080	153.42	5,075.6	115.64	18	.68
26.50	HF	1,149.5	304.62	1,149.5	304.62	101	26.76	101	26.76					740	196.10	740	196.10	740	196.10
3.30	NaOH	1,189	39.24	- 466	-15.44	6,171	203.71	4,516	149.03	1,478	48.77	- 178	- 5.87	6,080	200.64	5,850	193.05	2,637.5	87.04
5.00	NH_3	2,177	108.85	2,162	108.10					778	38.90	920.5	46.02	123	5.65	23.3	1.16	23.3	1.16
50.00	F_2	387.5	193.75	387.5	193.75									387.5	193.75	387.5	193.75	387.5	193.75
12.00	H_3PO_4	23.5	2.82	118.5	14.22	1,748	209.76	978	117.36	23.5	2.82	118.5	14.22						
1.28	H_2SO_4					875	11.20	21	.27					1	.01				
15.00	Oxalic acid					74.7	11.20	74.7	11.20					nil					
11.90	KOH					215	25.58	215	25.58										
2.10	Na_2CO_3			4,344	91.22	4,344	91.22					4,344	91.22						
13.51	$(NH_4)_2 SiF_6$					178	24.05	178	24.05										
9.40	$NaNO_2$					180	16.92												
355.00	$NaBiO_3$					30	106.50	30	106.50										
10.00	$Na_2Cr_2O_7 \cdot 2H_2O$					9.3	.93	9.3	.93					150	15.03				
14.08	$Fe(NH_4)_2(SO_4)_2 \cdot 6H_2O$					324	45.62	324	45.62										
27.61	$KMnO_4$					14.3	3.96	14.3	3.96										
199.37	KIO_3					88.7	176.78	33.5	66.79										
16.11	H_2O_2					34.7	5.58	34.7	5.58					10	1.61				
185.00	$La(NH_4)_2(NO_3)_5 \cdot xH_2O$					11.7	21.58	11.7	21.58										
56.98	Zr carbonate					.67	.38	.67	.38										
112.23	$Ce(NH_4)_2(NO_3)_6$					.93	1.05	.93	1.05										
2.56	$NaNO_3$					333	8.53							420	10.75	333.3	8.53		
8.42	NH_4NO_3	4,400	370.48	4,400	370.48					2,200	185.24	2,200	185.24						
0	N_2	20.5	—	20.5	—														
?	Cu wool	?	?	?	?														
12.00	$Al(NO_3)_3 \cdot 9H_2O$													8,760	1,051.20	7,886	946.32	5,626	675.12
18.00	Fe Sulfamate													255	45.90	239.2	43.06	181.9	32.74
14.50	Kerosene													2,630	381.35	2,246	325.67	1,521.6	220.63
	TOTAL		1,543.30		1,065.66		1,253.65		725.81		692.23		222.31		2,255.40		2,023.28		1,407.22

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COMPARISON OF DAILY CHEMICAL COSTS

Bases:
1) All processes are compared at a daily production rate of 4 metric tons of decontaminated uranium. Current slug metal is processed at a rate of 2 tons per day, and stored waste is depleted at a rate of 2 tons per day until an inventory of 2 years is reached in proposals 1 and 2, and until all stored waste is gone in other proposals.
2) All processes include costs of NF and F_2 for conversion of the final product to UF_6. UAP costs (proposals 1, 3, 5) are for dry hydrofluorination and hydrogen reduction. Others include the stoichiometric quantity of NF required for UF_4, plus 10% excess.
3) Costs shown are summed from the accompanying unit process costs by the formula shown at the column heads, and rounded to the nearest dollar.
4) Operating year 365 days.

Proposal → / Unit Process Sum ↓	1 2a+4a	2 2c+4c+4i	3 2c+2b+2a	4 2c+2e+2f+4i	5 2j+2a	6 2g+2e+2i	7 2g+2e+2i	8 2h+2i+2g+2i	9 2h+2d+2e+2i
MATERIAL									
HNO_3	2,619	2,193	1,934	1,508	1,354	1,141	1,141	1,304	1,304
NF	1,272	838	1,272	838	1,001	784	784	838	838
NaOH	564	951	455	842	140	673	673	956	956
NH_3	435	160	434	159	279	91	91	82	82
F_2	775	775	775	775	775	775	775	775	775
H_3PO_4	431	431	454	454	6	6	6	240*	240*
H_2SO_4	22	22	22	22					
Oxalic acid	22	22	22	22				22	22
KOH	51	51	51	51				51	51
Na_2CO_3	182	182							
$(NH_4)_2SiF_6$	48	48	48	48				48	48
$NaNO_2$	34	34	34	34					
$NaBiO_3$	213	213	213	213				213*	213*
$Na_2Cr_2O_7 \cdot 2\,H_2O$	2	2	2	2	30	30	30	2	2
$Fe(NH_4)_2(SO_4)_2 \cdot 6\,H_2O$	91	91	91	91				91	91
$KMnO_4$	8	8	8	8				8	8
$BiNO_3$	354	354	354	354				134*	134*
H_2O_2	11	11	11	11	3	3	3	11	11
$La(NH_4)_2(NO_3)_5 \cdot 4\,H_2O$	43	43	43	43				43	43
Zr carbonate	1	1	1	1				1	1
$Ce(NH_4)_2(NO_3)_6$	2	2	2	2				2	2
$NaNO_3$	17	17	17	17	22	22	22	17	17
NH_4NO_3	1,682	741	1,682	741	741	370	370	370	370
N_2	0		0		0				
Cu wool	?		?		?				
$Al(NO_3)_3 \cdot 9\,H_2O$		2,700		2,700	2,102	3,453	3,453	3,243	3,243
Fe sulfamate		131		131	92	157	157	152	152
Hexone		882		882	763	1,204	1,204	1,093	1,093
Total Daily Cost, 1952-53	8,680	10,905	7,725	9,965	7,597	8,710	8,710	9,697*	9,697*
Annual cost, 1952-53	3,168,000	3,980,000	2,820,000	3,637,000	2,771,000	3,178,000	3,178,000	3,539,000	3,539,000
Sum of Cost, 1949-58 Incl.	22,185,000	27,285,000	22,300,000	27,610,000	21,671,000	24,134,000	24,146,000	26,606,000	26,606,000
Annual Cost, 1959 and After	2,042,000	2,447,000	1,693,000	2,109,000	1,646,000	1,646,000	1,646,000	2,007,000	2,007,000

* Costs may be reduced by recovery of $BiPO_4$ process volume reduction.

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COMPARISON OF STORAGE OF NEUTRALIZED STORED WASTE
Volumes estimated in millions of gallons

Bases: 1) Decontaminated uranium produced at rate of four metric tons per day.
a) Irradiated slugs to be processed at rate of two metric tons per day.
b) Stored metal waste to be depleted at rate of two metric tons uranium per day.
2) Decontaminated uranium produced as 60% UHN except in cases 1, 3, and 5 where fluorination to UF_6 is required for adequate decontamination. Volumes of waste produced by fluorination steps indicated in parentheses.
3) Cost of storing waste solutions estimated at 40¢ per gallon. Where waste requires stainless steel tankage (all unit processes except $BiPO_4$) this estimate must be increased.
4) $BiPO_4$ process waste volumes include second cycle decontamination wastes now cribbed.
5) Concentrated volumes estimated for saturation at 20°C.
6) Final cycle wastes from solvent extraction processes assumed to be cribbed. (Total cribbed activity per ton U processed comparable with present 224 bldg. wastes.

ANNUAL WASTE DATA

	1949		1950		1951		1952		1953		1954		1955		1956		1957		1959 and after*		TOTAL WASTE VOLUME AND COST, 1949-1958 INCLUSIVE		CONCENTRATED NEUTRALIZED WASTE VOLUME	
	Current	Stored	Current	Stored	Current	Stored	Current	Stored	Current	Stored	Current	Stored	Current	Stored	Current	Stored	Current	Stored	Current	Stored	COST $ x 10^{-6}	VOLUME Gal. x 10^{-6}	1949-1958 Incl.	Annual 1959 and after
PROPOSAL 1																								
Plants Operating	$BiPO_4$-2T		$BiPO_4$-2T		$BiPO_4$-2T		$BiPO_4$-2T UAP - 4T		$BiPO_4$-2T UAP - 4T		$BiPO_4$-2T UAP - 4T		$BiPO_4$-2T UAP - 4T		$BiPO_4$-2T UAP - 4T		$BiPO_4$-2T UAP - 2T		$BiPO_4$-2T UAP - 2T		73.118	182.796	74.057	6.971
Vol Waste Produced	5.893		5.893		5.893		5.893	21,226 (.482)	5.893	21,226 (.482)	5.893	21,226 (.482)	5.893	21,226 (.482)	5.893	17,736 (.401)	5.893	10,613 (.241)	5.893	10,613 (.241)				
Tons U Stored-yr.end	3530		4260		4990		4260		3530		2800		2070		1460		1460		1460					
PROPOSAL 2																								
Plants Operating	$BiPO_4$-2T		$BiPO_4$-2T		$BiPO_4$-2T SX - 4T		$BiPO_4$-2T SX - 4T		$BiPO_4$-2T SX - 4T		$BiPO_4$-2T SX - 4T		$BiPO_4$-2T SX - 2T		$BiPO_4$-2T SX - 2T		$BiPO_4$-2T SX - 2T		$BiPO_4$-2T SX - 2T		60.336	150.841	135.795	12.299
Vol Waste Produced	5.893		5.893		5.893	15,750	5.893	15,750	5.893	15,750	5.893	13,161	5.893	7,875	5.893	7,875	5.893	7,875	5.893	7,875				
Tons U Stored-yr.end	3530		4260		3530		2800		2070		1460		1460		1460		1460		1460					
PROPOSAL 3																								
Plants Operating	$BiPO_4$-2T		$BiPO_4$-2T		$BiPO_4$-2T		$BiPO_4$-2T UAP - 2T UAP - 2T		$BiPO_4$-2T UAP - 2T UAP - 2T		$BiPO_4$-2T UAP - 2T UAP - 2T		$BiPO_4$-2T UAP - 2T UAP - 2T		$BiPO_4$-2T UAP - 2T UAP - 2T		$BiPO_4$-2T UAP - 2T UAP - 2T		$BiPO_4$-2T UAP - 2T UAP - 2T		66.973	165.181	48.656	2,838
Vol Waste Produced	5.893		5.893		5.893		10,708 (.241)	10,613 (.241)	10,708 (.241)	10,613 (.241)	10,708 (.241)	10,613 (.241)	10,708 (.241)	10,613 (.241)	10,708 (.241)	10,613 (.241)	10,708 (.241)	10,613 (.241)	10,708 (.241)	10,613 (.241)				
Tons U Stored-yr.end	3530		4260		4990		4260		3530		2800		2070		1340		610		00					
PROPOSAL 4																								
Plants Operating	$BiPO_4$-2T		$BiPO_4$-2T		$BiPO_4$-2T SX - 2T SX - 2T		$BiPO_4$-2T SX - 2T SX - 2T		$BiPO_4$-2T SX - 2T SX - 2T		$BiPO_4$-2T SX - 2T SX - 2T		$BiPO_4$-2T SX - 2T SX - 2T		$BiPO_4$-2T SX - 2T SX - 2T		$BiPO_4$-2T SX - 2T SX - 2T		$BiPO_4$-2T SX - 2T SX - 2T		48.709	122.773	106.668	6.344
Vol Waste Produced	5.893		5.893		8.004	7.875	8.004	7.875	8.004	7.875	8.004	7.875	8.004	7.875	8.004	6.580	8.004	7.875	8.004	7.875				
Tons U Stored-yr.end	3530		4260		3530		2800		2070		1340		610		00		00		00					
PROPOSAL 5																								
Plants Operating	$BiPO_4$-2T		$BiPO_4$-2T		$BiPO_4$-1T(77r)** Redox-1T(77r) Redox-2T(77r)		Redox-2T UAP - 2T		Redox-2T UAP - 2T		Redox-2T UAP - 2T		Redox-2T UAP - 2T		Redox-2T UAP - 2T		Redox-2T UAP - 2T		Redox-2T UAP - 2T					
Vol Waste Produced	5.893		5.893		3.302		2.438	10,613 (.241)	2.438	10,613 (.241)	2.438	10,613 (.241)	2.438	10,613 (.241)	2.438	10,613 (.241)	2.438	10,613 (.241)	2.438	10,613 (.241)	38.682	96.704	44.484	2,438
Tons U Stored-yr.end	3530		4260		4440		3710		2980		2250		1520		790		60		00					
PROPOSAL 6																								
Plants Operating	$BiPO_4$-2T		$BiPO_4$-2T		Same as proposal 5	SX - 2T	Redox-2T	SX - 2T	Redox-2T	SX - 2T	Redox-2T	SX - 2T	Redox-2T	SX - 2T	Redox-2T	SX - 2T	Redox-2T	SX - 2T	Redox-2T	SX - 2T	Redox-2T				
Vol Waste Produced	5.893		5.893		3.302	7.875	2.438	7.875	2.438	7.875	2.438	7.875	2.438	7.875	2.438	7.875	2.438	0.547	2.438		32.020	80.052	76.657	2,438
Tons U Stored-yr.end	3530		4260		3710		2980		2250		1520		790		60		00		00					
PROPOSAL 7																								
Plants Operating	$BiPO_4$-2T		$BiPO_4$-2T		Same as proposal 5 (4 yr)	Redox-2T	Redox-2T	Redox-2T	Redox-2T	Redox-2T	Redox-2T	Redox-2T	Redox-2T	Redox-2T	Redox-2T	Redox-2T	Redox-2T	Redox-2T	Redox-2T	Redox-2T	Redox-2T				
Vol Waste Produced	5.893		5.893		3.302	3.918	2.438	7.875	2.438	7.875	2.438	7.875	2.438	7.875	2.438	7.875	2.438	4.615	2.438		32.025	80.062	76.668	2.438
Tons U Stored-yr.end	3530		4260		4080		3350		2620		1890		1160		430		00		00					
PROPOSAL 8																								
Plants Operating	$BiPO_4$-2T		$BiPO_4$-2T		SX-PO_4-2T SX - 2T		SX-PO_4-2T SX - 2T		SX-PO_4-2T SX - 2T		SX-PO_4-2T SX - 2T		SX-PO_4-2T SX - 2T		SX-PO_4-2T SX - 2T		SX-PO_4-2T		SX-PO_4-2T					
Vol Waste Produced	5.893		5.893		5.125	7.875	5.125	7.875	5.125	7.875	5.125	7.875	5.125	7.875	5.125	6.580	5.125		5.125***		39.496	98.742	83.636	3.634
Tons U Stored-yr.end	3530		4260		3530		2800		2070		1340		610		00		00		00					
PROPOSAL 9	IDENTICAL WITH PROPOSAL 8																				IDENTICAL WITH PROPOSAL 8			

NOTES: * Year 1958 not shown since only part time operations are required for proposals 3 & 5. All others would be at 1959 operating rate.

** Assumed operation of one $BiPO_4$ plant with the first Redox plant at one ton capacity each for ½ year, the second Redox plant being established the second half of the year.

*** The SX-PO_4 coupling process, producing a small volume Pu feed to the PO_4 decontamination, would probably permit reduction of the waste volumes from the phosphate process. Of the 5.125 million gallons annual waste shown, 3.022 million gallons are from the phosphate decontamination cycles.

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