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September 2, 1977

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ALTERNATE FUEL CYCLE TECHNOLOGIES
NITRATE-TO-OXIDE CONVERSION PROJECT
PROGRESS REPORT
JANUARY-JUNE 1977

George D. Lehmkuhl

Chemistry Research and Development
PROCESS CHEMISTRY AND ENGINEERING GROUP

Rockwell International

Atomics International Division
Rocky Flats Plant
P.O. Box 464
Golden, Colorado 80401

U.S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
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UC-78 LIGHT WATER
REACTOR TECHNOLOGY
TID-4500-R65

**ALTERNATE FUEL CYCLE TECHNOLOGIES
NITRATE-TO-OXIDE CONVERSION PROJECT
PROGRESS REPORT
JANUARY-JUNE 1977**

George D. Lehmkuhl

Chemistry Research and Development
PROCESS CHEMISTRY AND ENGINEERING GROUP

SUBJECT DESCRIPTORS

Plutonium Processing
Plutonium Nitrates
Plutonium Oxides

**ROCKWELL INTERNATIONAL
ATOMICS INTERNATIONAL DIVISION
ROCKY FLATS PLANT
P. O. BOX 484
GOLDEN, COLORADO 80401**

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for the
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U. S. Energy Research and Development Administration**

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ACKNOWLEDGMENTS

Appreciation is expressed for assistance in the preparation of this report to the following members of the PNO Project Team: R. Monte Greinetz, David H. Neal, Kenneth R. Souply, Walter E. Sperry, and Steven J. Winston.*

*Energy, Incorporation, Idaho Falls, Idaho.

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ABSTRACT

Work is being done at the Rocky Flats Plant (RFP) under contract from the Savannah River Operations Office (SR00) of the U.S. Energy Research and Development Administration (ERDA) to critically analyze and evaluate existing technology for converting plutonium nitrate to plutonium oxide, and to recommend flow sheets and equipment for this process.

Seven such processes were compared using an expanded process-comparison scheme. The results of the comparison differed somewhat from the initial comparison made in September, 1976.

The direct calcination methods, headed by the screw calciner process, received the highest ratings when operating experience was considered with a small weighting factor. These methods are much simpler than the others. The oxalate precipitation methods, headed by the plutonium(IV) oxalate precipitation and calcination process, received highest ratings when operating experience was strongly considered. Thus, in the long term, the screw calciner or other direct-conversion methods should be developed. For a plant to be built in the short term, however, an oxalate precipitation method should be used since a larger amount of experience exists with these processes.

The block flow diagrams, material balances, and equipment flow sheets for each of the seven processes compared are included in this report. A process-design criterion is being prepared for a mechanical (screw calciner) direct-denitration process, and includes process flow sheets, a material balance, a process description, equipment performance specifications, the control philosophy and specifications, the operating philosophy, and a general process layout.

INTRODUCTION

A study of processes for converting plutonium nitrate to plutonium oxide (PNO) was begun at the RFP in March, 1976,¹ as a part of the Light Water Reactor Fuel Recycle Program funded by ERDA through SR00. A survey of literature, ERDA installations, and industrial plants and laboratories produced a list of processes for PNO conversion. These processes were screened and the following seven were chosen for further study:^{2,3}

1. Fluid Bed Direct-Denitration
2. Screw Calciner Mechanical Direct-Denitration
3. Plutonium(IV) Oxalate Precipitation and Calcination
4. Plutonium(III) Oxalate Precipitation and Calcination
5. Batch Direct-Denitration
6. Sol-Gel
7. Peroxide Precipitation and Calcination

¹E. D. Erickson. Light Water Reactor Fuel Recycle Program, Plutonium Nitrate-to-Oxide Conversion Project. Initial Report, April 1976. U.S. ERDA RFP-2552. January 17, 1977.

²G. D. Lehmkuhl. Light Water Reactor Fuel Recycle Program, Plutonium Nitrate-to-Oxide Conversion Project Progress Report, May-June 1976. U.S. ERDA RFP-2573. January 17, 1977.

³G. D. Lehmkuhl. Light Water Reactor Fuel Recycle Program, Plutonium Nitrate-to-Oxide Conversion Project Progress Report, July-September 1976. U.S. ERDA RFP-2590. February 7, 1977.

Information was gathered on each of the seven and an initial set of process-comparison criteria was developed. The processes were compared in September 1976 using the information initially gathered on each, and using the initial set of comparison criteria. All of the direct-denitration processes received higher ratings than those using precipitation-calcination. Fluid bed direct-denitration was first, followed closely by screw calciner mechanical direct-denitration and batch direct-denitration.

The seven processes were studied in greater detail so an information package could be prepared for each. The more detailed process information and more detailed comparison criteria were used to make an updated comparison of the seven. A discussion of the information packages and the process comparison is included in this report.

CURRENT ACHIEVEMENTS

Information Packages

One of the major objectives of this program is to collect information on each of the seven processes being studied and to publish a report covering each process. The reports can be used as a basis for further studies or when making comparisons of alternative processes. These reports contain:

1. A history of the process.
2. A process description, including flow sheets and a material balance.
3. Process advantages and disadvantages.
4. Suggested research and development.
5. Pertinent research references.

The process flow sheets have all been completed and are included in the appendix to this report. This appendix also contains a block flow diagram and material balance information for each of the processes being studied.

The status of each of the process information package reports as of June 30, 1977, is:

1. Fluid bed direct-denitration -- report published.⁴
2. Screw calciner mechanical direct-denitration -- report drafted, reviewed, and submitted for publication.
3. Plutonium(IV) oxalate precipitation and calcination -- report drafted and being reviewed.
4. Plutonium(III) oxalate precipitation and calcination -- report 70% completed.
5. Batch direct-denitration -- report draft completed.
6. Sol-Gel -- report draft completed.
7. Peroxide precipitation and calcination -- report 30% completed.

Comparison Criteria

An expanded set of process comparison criteria was developed for use in choosing a primary conversion process. The criteria were designed to contain all pertinent factors and to minimize

⁴K. R. Souply and D. H. Neal. Fluid Bed Direct Denitration Process for Plutonium Nitrate to Oxide Conversion. U.S. ERDA RFP-2600. June 1, 1977.

subjectivity in the comparison process. All factors in the initial process-comparison criteria² were included in the new criteria. However, there is not a one-to-one correlation between the old and new criteria due to the differences in structure.

The structure of the criteria is shown in Figure 1. Information considered for each is shown in Figures 1 and 2. Raw data were collected for each process and manually manipulated to calculate normalized input data for a computer program. The data input points to the computer program are shown in Figure 1. Weighting factors were used at each step of the comparison to relate the relative importance of the different criteria. The comparison ratings calculated at tertiary and secondary levels were normalized before being rated at the next higher level. A complete explanation of the criteria and the rating process will be published in a separate report.

Process Comparison

The seven processes were rated using the process-comparison criteria. Input data were fed into the computer as described in the previous section. These data were calculated from the information collected for the process information packages.

Weighting factors were chosen at the three levels to give the proper relative importance to the criteria. These factors were chosen to give the same significance to important items in the new criteria as they had in the old. The tertiary factors, space, equipment, operational concerns, accountability, process requirements, and maintenance, were given weighting factors of 3, 1, 2, 3, 1, and 3, respectively. Secondary factors, capital and operating cost, were given equal weighting. The weighting

factors at the primary level were 9, 10, 8, 6, and 7, respectively, for cost, remote replacement, chemical hazards, automated operations, and waste treatment. The primary criterion of operating experience was varied from a low, 5, to a very high, 40, weighting factor to determine the effect of previous operating experience on the primary process.

The effect of varying the importance of operating experience is shown in Tables I, II, and III. These tables show input data and calculated data at each step in the evaluation process. The final evaluation is given in the top row of each table directly under the process numbers with the highest number being best. The direct-denitration processes are highest, followed by the precipitation processes when the operating experience has a low value, 5, as in Table I. The screw calciner mechanical direct-denitration process is primary in this case. In Table II, the weight of experience is increased to 11, and the precipitation processes and direct-denitration processes are interspersed in importance. When the experience factor is very large, 40, as in Table III, the oxalate precipitation processes are definite leaders over the direct-denitration processes. The plutonium(IV) oxalate precipitation and calcination process was primary in this case.

A sensitivity analysis was also done on the other weighting factors. Each factor was varied until the indicated primary process dropped to second place. There was no strong sensitivity to any of the weighting factors.

The results of the process comparison described above showed that different strategies should be adopted depending

TABLE I. PNO Conversion Process Analysis, Low Experience Factor

	<u>Process Number^a</u>							<u>Weighting Factors</u>	
	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6^b</u>	<u>7</u>		
Recommendation	5.58	5.76	5.38	4.69	5.60	1.97	3.96		
Cost	6.17	6.22	4.96	5.22	6.32	0.0	5.15	9.0	
Capitol	6.22	6.10	4.72	5.32	6.20	0.0	5.72		1.0
Space ^c	6.20	6.10	4.60	5.40	6.20	0.0	5.80		3.0
Equipment ^c	6.30	6.10	5.10	5.10	6.20	0.0	5.50		1.0
Operating	6.12	6.33	5.20	5.11	6.43	0.0	4.58	1.0	
Operational Concerns ^c	6.50	6.90	5.60	6.00	6.90	0.0	0.60		2.0
Accountability ^c	5.80	6.10	4.90	5.70	6.30	0.0	5.60		3.0
Process Requirements ^c	6.70	6.90	5.30	1.30	6.90	0.0	5.80		1.0
Maintenance ^c	6.00	6.00	5.20	5.20	6.10	0.0	5.80		3.0
Remote Replacement ^c	6.00	6.10	5.30	5.30	6.10	0.0	5.50	10.0	
Chemical Hazards ^c	4.20	4.20	3.80	4.00	4.20	4.20	3.80	8.0	
Automated Operations	6.40	6.80	5.60	6.00	7.10	0.20	0.90	6.0	
Waste Treatment ^c	6.96	7.55	5.07	0.46	7.56	2.67	2.98	7.0	
Operating Experience ^c	3.00	3.00	9.00	8.00	1.00	7.00	4.00	5.0	

a. 1 - Fluic Bed 2 - Screw Calciner 3 - PuIV Oxalate 4 - PuIII Oxalate
 5 - Batch 6 - Sol Gel 7 - Peroxide Precipitation

b. Zeros for this process result from the large numbers of equipment required by this process relative to the other processes.

c. Indicates Input Data.

TABLE II. PNO Conversion Process Analysis, Medium Experience Factor

<u>Factor</u>	<u>Process Number^a</u>							<u>Weighting Factors</u>	
	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6^b</u>	<u>7</u>		
Recommendation	5.28	5.44	5.81	5.08	5.06	2.56	3.96		
Cost	6.17	6.22	4.96	5.22	6.32	0.0	5.15	9.0	
Capitol	6.22	6.10	4.72	5.32	6.20	0.0	5.72	1.0	
Space ^c	6.20	6.10	4.60	5.40	6.20	0.0	5.80		3.0
Equipment ^c	6.30	6.10	5.10	5.10	6.20	0.0	5.50		1.0
Operating	6.12	6.33	5.20	5.11	6.43	0.0	4.58	1.0	
Operational Concerns ^c	6.50	6.90	5.60	6.00	6.90	0.0	0.60		2.0
Accountability ^c	5.80	6.10	4.90	5.70	6.30	0.0	5.60		3.0
Process Requirements ^c	6.70	6.90	5.30	1.30	6.90	0.0	5.80		1.0
Maintenance ^c	6.00	6.00	5.20	5.20	6.10	0.0	5.80		3.0
Remote Replacement ^c	6.0	6.10	5.30	5.30	6.10	0.0	5.50	10.0	
Chemical Hazards ^c	4.20	4.20	3.80	4.00	4.20	4.20	3.80	8.0	
Automated Operations ^c	6.40	6.80	5.60	6.00	7.10	0.20	0.90	6.0	
Waste Treatment ^c	6.96	7.56	5.07	0.46	7.56	2.67	2.98	7.0	
Operational Experience ^c	3.00	3.00	9.00	8.00	1.00	7.00	4.00	11.0	

a. 1 - Fluid Bed 2 - Screw Calciner 3 - PuIV Oxalate 4 - PuIII Oxalate
5 - Batch 6 - Sol Gel 7 - Peroxide Precipitation

b. Zeros for this process result from the large numbers of equipment required by this process relative to the other processes.

c. Indicates Input Data.

TABLE III. PNO Conversion Process Analysis, High Experience Factor

Factor	Process Number ^a							Weighting Factors	
	1	2	3	4	5	6 ^b	7		
Recommendation	4.45	4.55	6.96	6.14	3.59	4.17	3.98		
Cost	6.17	6.22	4.96	5.22	6.32	0.0	5.15	9.0	
Capitol	6.22	6.10	4.72	5.32	6.20	0.0	5.72	1.0	
Space ^c	6.20	6.10	4.60	5.40	6.20	0.0	5.80		3.0
Equipment ^c	6.30	6.10	5.10	5.10	6.20	0.0	5.50		1.0
Operating	6.12	6.33	5.20	5.11	6.43	0.0	4.58	1.0	
Operational Concerns ^c	6.50	6.90	5.60	6.00	6.90	0.0	0.60		2.0
Accountability ^c	5.80	6.10	4.90	5.70	6.30	0.0	5.60		3.0
Process Requirements ^c	6.70	6.90	5.30	1.30	6.90	0.0	5.80		1.0
Maintenance ^c	6.00	6.00	5.20	5.20	6.10	0.0	5.80		3.0
Remote Replacement ^c	6.0	6.10	5.30	5.30	6.10	0.0	5.50	10.0	
Chemical Hazards ^c	4.20	4.20	3.80	4.00	4.20	4.20	3.80	8.0	
Automated Operations ^c	6.40	6.80	5.60	6.00	7.10	0.20	3.90	6.0	
Waste Treatment ^c	6.96	7.56	5.07	0.46	7.56	2.67	2.98	7.0	
Operating Experience	3.00	3.00	9.00	8.00	1.00	7.00	4.00	40.0	

a. 1 - Fluid Bed 2 - Screw Calciner 3 - PuIV Oxalate 4 - PuIII Oxalate
 5 - Batch 6 - Sol Gel 7 - Peroxide Precipitation

b. Zeros for this process result from the large numbers of equipment required by this process relative to the other processes.

c. Indicates Input Data.

upon whether the conversion facility is to be built in the near term or in the future. A plant built in the near term should use an oxalate precipitation process because of the large amount of operating experience. A future plant should use a direct calcination method which could undergo additional development work in the interim.

Primary Process Criteria

Process criteria are being prepared for the screw calciner mechanical direct-denitration process. These criteria include a process description, material balance, equipment flow diagram, and equipment performance specifications. Also included, are the control philosophy and specifications, the operating philosophy, and a general process layout. These criteria are 40% complete.

FUTURE WORK

All seven of the plutonium nitrate-to-oxide conversion process information packages will be written, reviewed, typed, and sent to Rocky Flats Research and Engineering Administration before the end of the fourth quarter of FY-1977 for publication. The process criteria for the screw calciner mechanical direct-denitration process will be completed. Initial work will begin on the direct-denitration experimental unit.

Information will be gathered on co-processing of uranium/plutonium nitrates to produce mixed oxides. An investigation of published and unpublished literature will be included. The adaptability of processes normally used for uranium or plutonium separately will also be considered. The suitability of the product for pellet manufacture will be a prime consideration.

ILLUSTRATIONS

Figures 1 and 2

FIGURE 1. Process-Comparison Criteria Structure.

FIGURE 2. Process-Comparison Criteria Factors.

RFP-2591
APPENDIX

A1 through A8
(27 Sheets)

LEGEND SHEET FOR "PNO" FLOW SHEETS

EQUIP. SYMBOL

MISCELLANEOUS

LETTER SYMBOL

—

P

P

P

B

C

E

D,R

J

A
CV
CY
F
FL
H
ME
W
Z
STM
COND
PW
CWS
CWR
CHWS
CHWR

DESCRIPTION

LINE IDENTIFICATION

CENTRIFUAL PUMP

GEAR PUMP

DIAPHRAGM PUMP

BLOWER

COMPRESSOR

HEAT EXCHANGER

VESSEL , REACTOR

JET,EDUCTOR

AGITATOR
CONVEYOR
CYCLONE
FURANCE
FILTER
HOPPER
MISCELLANEOUS MECHANICAL EQUIP.
DRYER
VIBRATOR
STEAM
CONDENSATE
PROCESS WATER
COOLING WATER SUPPLY
COOLING WATER RETURN
CHILLED WATER SUPPLY
CHILLED WATER RETURN

A1. PNO. FLOW SHEET LEGEND

A ORIGINAL ISSUE		2-3-77		A1		ERDA		CLASS		JOB NO.	
DESIGNED		BY		DATE		U.S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION		ROCKY PLATS AREA OFFICE		GOLDEN, COLORADO	
DRAWN		S.HATCH		2-3-77							
CHECKED											
APPROVED											
SUBMITTED											
APPROVED											
ERDA											
SCALE											
D											
A1											

DIRECT DENITRATION (FLUID BED)

CONT. FROM SHT. 1

STREAM COMPONENT	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	
Pu(NO ₃) ₄	TRACE												TRACE	TRACE	TRACE					
PuO ₂		TRACE	TRACE	TRACE						TRACE										
H ₂ O	6,535	2,497	6,053	18,068		2,340#/HR	16,783		20#/HR	1,285		16,783	6,535	12,015	23,318	10,428	19,946			
HNO ₃	272	TRACE	2,848	2,848			2,041			807		2,041	272	TRACE	2,313					
NO ₂		2,722														2,722				
NO		365														365				
O ₂ (FROM REACTION)		721														721				
AIR		213,831														213,831				
METAL IONS																				
SULFUR																				
HALOGENS (F&Cl)																				
STEAM								46.8#/HR												
TOTAL GMS/HR.	6,807	220,136	8,901	20,916		2,340#/HR	18,824	46.8#/HR	20#/HR	2,092		18,824	6,807	12,015	25,631	228,067	19,946			
Pu, GMS/L	10 ⁻⁴		10 ⁻⁴	10 ⁻⁴									10 ⁻⁴	10 ⁻⁴	10 ⁻⁴	< 10 ⁻⁴				
FLOW, L/HR	6.7	194,950	7.5	19.5		4.7GPM	17.8		0.04GPM	1.7		17.8	6.7	12.1	205,123	20		119.2		
PRESS, PSIA	PUMP	SYSTEM	PUMP	PUMP			PUMP					PUMP	PUMP	PUMP	PUMP	SYSTEM	SYSTEM		PUMP	
TEMP, °C	40	40	40	< 40			40			50			AMBIENT	AMBIENT	- 40	AMBIENT	40	27	- 40	
MOLARITY	0.5M HNO ₃		6.1M HNO ₃	2.4			2M HNO ₃			10M HNO ₃			2M HNO ₃	0.5M HNO ₃		1.6M HNO ₃				
PHASE	LIQUID	GAS	LIQUID	LIQUID		LIQUID	LIQUID	VAPOR	LIQUID	LIQUID	LIQUID	LIQUID	LIQUID	LIQUID	LIQUID	VAPOR	LIQUID	LIQUID	LIQUID	

A2. (Continued)

A ORIGINAL ISSUE		1-7-77		DATE		AI		ERDA		CLAIM		JOB NO.	
DESIGNED BY		D. NEAL		DATE		12-15-76		U.S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION		ROCKY FLATS AREA OFFICE		GOLDEN, COLORADO	
DRAWN BY		S. HATCH		DATE		1-7-77							
CHECKED BY													
APPROVED BY													
EQUIPMENT FLOW SHEET & MATERIAL BALANCE													
FLUIDIZED BED DIRECT DENITRATION													
SCALE		APPROVED		AI		ERDA		D		A		2-2	

DIRECT DENITRATION (SCREW CALCINER)

A3. (4 Sheets) SCREW CALCINER MECHANICAL DIRECT-DENITRATION

D-1 THRU 5
FEED STORAGE TANK
SST
GEOMETRICALLY SAFE "SLAB TANKS"
10,000 LITER CAPACITY TOTAL
(30 TANKS REG.)

P-1
PUMP
SST
CANNED PUMP
1 GPM

D-6
EVAPORATOR
SST
GEOMETRICALLY SAFE
25 L/H CAPACITY

E-2
REBOILER
SST SHELL & TUBE
DUTY: 25,000 BTU/HR

P-3
CONDENSATE TRANSFER PUMP
SST
CANNED PUMP
0.1 GPM

P-4
CALCINER FEED PUMP
SST
.1 GPM METERING PUMP

E-1
CONDENSER
SST SHELL & TUBE
DUTY: 25,000 BTU/HR.

D-7
CONDENSER SUMP TANK
SST
GEOMETRICALLY SAFE
10 LITER CAPACITY

P-2
BOTTOMS PUMP
SST
CANNED PUMP
0.5 GPM

D-9
CALCINER FEED STORAGE TANKS
SST
GEOMETRICALLY SAFE SLAB TANK
2000 LITER CAPACITY

STREAM	100	101	102	119	120						
GMS/HR COMPONENT					CHWS						
Pu (NO ₃) ₄	8,489	8,489									
H ₂ O	15,214	10,000	5,214		1,400#/HR						
HNO ₃	3,156	2,950	206								
URANIUM	42	42									
SULFUR	4	4									
HALIDES (F&Cl)	.6	.6									
METAL IONS	42	42									
NO											
NO ₂											
O ₂											
PuO ₂											
ROOM AIR											
STEAM				20#/HR							
TOTAL GMS/HR	26,947	21,527	5,420	20#/HR	1,400#/HR						
Pu, GMS/L	250	372.75									
FLOW, L/HR	16.7	11.2	5.5		2.8 GPM						
PRESS, PSIA	SYSTEM	SYSTEM	SYSTEM	100	SYSTEM						
TEMP, °C	AMB	109	AMB		15						
MOLARITY	3 HNO ₃	4.7 HNO ₃	.6 HNO ₃								
PHASE	LIQUID	LIQUID	LIQUID	VAPOR	LIQUID						

NOTES:

1. STREAM FLOW RATES GIVEN ARE FOR THE TOTAL PLANT THROUGHPUT. THROUGHPUT FOR EQUIPMENT SPECIFIED IN PARALLEL IS EQUAL TO THE TOTAL PLANT THROUGHPUT DIVIDED BY THE NUMBER OF UNITS IN PARALLEL.
2. UNLESS OTHERWISE SPECIFIED GEOMETRICALLY SAFE SLAB TANKS INSIDE WIDTH & HEIGHT SHALL BE STANDARDIZED TO 4" X 48" RESPECTIVELY, WITH TANK LENGTH LEFT AS A VARIABLE TO MEET VOLUME REQUIREMENTS. OTHER GEOMETRICALLY SAFE, TANKS, REACTORS, & HEAT EXCHANGERS SHALL BE 5" ID CYLINDRICAL VESSELS OF VARIABLE LENGTH.
3. GAS VOLUME FLOW RATES ARE GIVEN AT S.T.P.
4. WHERE NOTED RASCHIG RING (BORON GLASS) PACKED TANKS OF EQUAL NET VOLUME MAY BE SUBSTITUTED FOR TANKS SPECIFIED GEOMETRICALLY SAFE.
5. ALL ROOM AIR DRAWN THROUGH HOOD & SIZING SCREEN (ME-6) IS FILTERED BY FL-2.

A3. (Continued)

A ORIGINAL ISSUE		1-20-77		2		AT		ERDA		CLASS		JOB NO.	
TOLERANCES		BY		DATE		U.S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION		ROCKY FLATS AREA OFFICE		GOLDEN, COLORADO			
FRAC. ±		DESIGNED		W. SPERRY		1-13-77		ROCKWELL INTERNATIONAL		ATOMIC INTERNATIONAL DIVISION			
ANGLE ±		DRAWN		S. HATCH		1-20-77		ERDA CONTRACT E (29-2)-3533		GOLDEN, COLORADO 80401			
DEC. ±		CHECKED						ROCKWELL INTERNATIONAL		ATOMIC INTERNATIONAL DIVISION			
UNLESS NOTED OTHERWISE		APPROVED						ROCKY FLATS PLANT		GOLDEN, COLORADO 80401			
REMOVE BORDERS AND SHARP EDGES								FLOW SHEET & MATERIAL BALANCE		SCREW CALCINER			
NEXT ASSEMBLY								CONVERSION OF Pu(NO ₃) ₄ TO PuO ₂					
SCALE		SUBMITTED						SIZE		DRAWING NUMBER		ISSUE	
		APPROVED		AT		ERDA		D				A 1 of 3	

Pu (IV) OXALATE

CONT. FROM SHT. 1

STREAM COMPONENT	116	117	115	119	120	121	122	123	124	125	126	127	128	129	130	113	132	133	134	135
Pu(NO ₃) ₄										TRACE						TRACE			TRACE	
Pu(C ₂ O ₄) ₂										4						217	121		4	
PuO ₂	TRACE							TRACE							TRACE					
H ₂ O ₂																				
H ₂ C ₂ O ₄																				
H ₂ O	2,129	132,421	34	17,000 LBS./HR.	1,948		2,088	2,270	134,691	883					2,129	127,994			126,119	19 LBS./HR.
HNO ₃	38	19,727			TRACE			38	19,765	613					38	15,111			15,111	
CO ₂ or CO ₂ &NO ₂	2,498		1,125		2,498										2,498					
AIR	32,991				32,991										32,991					
METAL IONS										127						127			127	
SULFUR										27						27			27	
HALOGENS (F&Cl)										4						4			4	
STEAM or BRINE																				
TOTAL GMS/HR	37,656	142,148	1,159	17,000 LBS./HR.	37,437	381 LBS./HR.	2,088	2,308	154,456	1,658			294 LBS./HR.		37,656	144,044			141,956	19 LBS./HR.
Pu, GMS/L																				
Flow, L/HR	30,675	142	748		33,419		2.1	2.3	155	1.2						0.93			0.03	
PRESS, PSIA	SYSTEM	PUMP	SYSTEM		SYSTEM	30		PUMP	SYSTEM						SYSTEM	SYSTEM			SYSTEM	
TEMP, °C	50°C	40°C	40°C	20	42.5°C		27	AMB	AMB	20°C			20°C		190°C	10			10	20
MOLARITY		2.3N HNO ₃							2.2N HNO ₃	8.2N HNO ₃						2.4N HNO ₃			2.4N HNO ₃	
BATCH QUANTITY																				
PHASE	GAS	LIQUID	VAPOR	LIQUID	GAS	VAPOR	LIQUID	LIQUID	LIQUID	LIQUID			LIQUID		GAS	LIQUID	LIQUID	LIQUID	LIQUID	LIQUID

A4. (Continued)

ORIGINAL ISSUE		11-3-76		DATE		AI		ERDA		CLASS		JOB NO.	
DESIGNED		D. NEAL		10-29-76		ROCKWELL INTERNATIONAL		ATOMIC INTERNATIONAL DIVISION		ERDA CONTRACT E (10-2)-3832		ROCKWELL INTERNATIONAL	
DRAWN		S. HATCH		11-3-76		ROCKWELL INTERNATIONAL		ATOMIC INTERNATIONAL DIVISION		ERDA CONTRACT E (10-2)-3832		ROCKWELL INTERNATIONAL	
CHECKED						ROCKWELL INTERNATIONAL		ATOMIC INTERNATIONAL DIVISION		ERDA CONTRACT E (10-2)-3832		ROCKWELL INTERNATIONAL	
APPROVED						ROCKWELL INTERNATIONAL		ATOMIC INTERNATIONAL DIVISION		ERDA CONTRACT E (10-2)-3832		ROCKWELL INTERNATIONAL	
SUBMITTED						ROCKWELL INTERNATIONAL		ATOMIC INTERNATIONAL DIVISION		ERDA CONTRACT E (10-2)-3832		ROCKWELL INTERNATIONAL	
APPROVED						ROCKWELL INTERNATIONAL		ATOMIC INTERNATIONAL DIVISION		ERDA CONTRACT E (10-2)-3832		ROCKWELL INTERNATIONAL	
APPROVED						ROCKWELL INTERNATIONAL		ATOMIC INTERNATIONAL DIVISION		ERDA CONTRACT E (10-2)-3832		ROCKWELL INTERNATIONAL	
SCALE						ROCKWELL INTERNATIONAL		ATOMIC INTERNATIONAL DIVISION		ERDA CONTRACT E (10-2)-3832		ROCKWELL INTERNATIONAL	
SIZE						ROCKWELL INTERNATIONAL		ATOMIC INTERNATIONAL DIVISION		ERDA CONTRACT E (10-2)-3832		ROCKWELL INTERNATIONAL	
DRAWING NUMBER						ROCKWELL INTERNATIONAL		ATOMIC INTERNATIONAL DIVISION		ERDA CONTRACT E (10-2)-3832		ROCKWELL INTERNATIONAL	
ISSUE						ROCKWELL INTERNATIONAL		ATOMIC INTERNATIONAL DIVISION		ERDA CONTRACT E (10-2)-3832		ROCKWELL INTERNATIONAL	
SHEET						ROCKWELL INTERNATIONAL		ATOMIC INTERNATIONAL DIVISION		ERDA CONTRACT E (10-2)-3832		ROCKWELL INTERNATIONAL	
D 25828-2						ROCKWELL INTERNATIONAL		ATOMIC INTERNATIONAL DIVISION		ERDA CONTRACT E (10-2)-3832		ROCKWELL INTERNATIONAL	
A						ROCKWELL INTERNATIONAL		ATOMIC INTERNATIONAL DIVISION		ERDA CONTRACT E (10-2)-3832		ROCKWELL INTERNATIONAL	
OF						ROCKWELL INTERNATIONAL		ATOMIC INTERNATIONAL DIVISION		ERDA CONTRACT E (10-2)-3832		ROCKWELL INTERNATIONAL	

Pu (III) OXALATE

STREAM	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	122	148	149	150	151	152
GMS/HR COMPONENT																							
Pu(NO3)4	8,471		8,471																				
Pu(NO3)3			905																				
Pu2(C2O4)3 · 10H2O							9,376				93.8												
H2O	15,186	215	29,711	20,975			50,901	44,473	34,690		128,290	26,642	13,135	7,747	13,135	147,185	41	14,525					
HNO3	3,151		20,380				20,380				24,018	882	17,060	1,245	17,060	23,655		17,229					
N2H4		27					27				27					26							
H8C6O6				3,995			3,995				3,995			200		3,795							
H2C2O4								3,360	2,625		3,360	756		206		3,910							
GASEOUS REACTION PRODUCTS (H2O, H2, CO2, HNO2)																							
AIR										2,131							2,131						
NONVOLATILE IMPURITIES	177		177				177				177			177									
STEAM																							
TOTAL GMS/HR	26,985	242	59,644	24,970			84,856	47,833	37,315	2,131	168,854	28,280	30,195	17,486	31,075	178,768	2,172	32,659					391#/HR
Pu, GMS/L	250		11.5	22.7			73.6				31.8				20.2	0.65		21.3					
FLOW, L/HR	16.7	.24	40.6				63.54	46.7	36.4	1,500	147	28	22.6		22.6	164	1,500	23.9					
PRESS, PSIA	PUMP	PUMP	PUMP	PUMP		SYSTEM	PUMP	PUMP	PUMP	16.1	GRAVITY	PUMP	PUMP		GRAVITY	VACUUM	SYSTEM	PUMP	PUMP	PUMP	30	SYSTEM	SYSTEM
TEMP, °C	AMB	AMB	AMB	AMB		AMB	AMB	AMB	AMB	AMB	25°C	AMB	AMB		AMB	AMB	AMB	120	25°C	25°C	SYSTEM	15	27
MOLARITY	3M HNO3	3.57M N2H4	8HNO3	1M H8C6O6			0.05M H8C6O6	0.8H2C2O4	0.8H2C2O4		25H2C2O4	3H2C2O4	12MHNO3		28H2C2O4	2.3HNO3		11.4MHNO3					
BATCH QUANTITY		0.1L	17.3L	9.7L			27.1L	20L	15.6L	1500L													
PHASE	LIQUID	LIQUID	LIQUID	LIQUID		GAS	LIQUID	LIQUID	LIQUID	GAS	SLURRY	LIQUID	LIQUID	SOLID	SLURRY	LIQUID	VAPOR	LIQUID	LIQUID	LIQUID	VAPOR	LIQUID	LIQUID

NOTES

1. FLOWS SHOWN FOR PARALLEL TRAINS ARE TOTALS.
2. ASSUMES THAT 10% OF CAKE IS WASHED OFF.
3. ASSUMES THAT 1% OF Pu(NO3)3 IS NOT REACTED.
4. ASSUMES BREAKTHROUGH OF 1% OF Pu2(C2O4)3 · 10H2O.
5. ASSUMES WASH FLOW NECESSARY TO GET 20g Pu/L.
6. D-2 & D-3 ALTERNATE IN PROCESSING BATCHES OF FEED STOCK. FLOWS OF N2H4 & H8C6O6 ARE FOR PREPARATION IN A SINGLE VESSEL. RATE SHOWN IS AN HOURLY AVERAGE.
7. BATCH CYCLE TIME IS ASSUMED TO BE 1 HOUR, YIELDING 2.33 CONTINUOUSLY OPERATING TRAINS. PRECIPITATION OCCURS IN R-1 WITH STOICHIOMETRIC H2C2O4, FOLLOWED BY DIGESTION IN R-2 WITH EXCESS H2C2O4. BATCH SIZE IS 2 KG PU.
8. ASSUME LIQUID RETENTION BY CAKE OF 5% BY WEIGHT.

ORIGINAL ISSUE 4-4-77

DESIGNED BY D. NEAL **DATE** 3-9-77

DRAWN BY S. HATCH **DATE** 4-4-77

CHECKED BY [Signature]

APPROVED BY [Signature]

REMOVED BY [Signature]

SCALE [Signature]

U.S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

ROCKWELL INTERNATIONAL

ATOMIC INTERNATIONAL DIVISION

ERDA CONTRACT E (29-2)-3533

ROCKWELL PLANT GOLDEN, COLORADO 80401

EQUIPMENT FLOW SHEET & MATERIAL BALANCE

Pu(III) OXALATE PROCESS

DRAWING NUMBER [Blank] **ISSUE** [Blank] **SHEET** 1 of 4

A5. (Continued)

A ORIGINAL ISSUE		4-11-77		A1		ERDA CLASS		JOB NO.	
DESIGNED BY		D. NEAL		3-9-77		U.S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION			
DRAWN BY		S. HATCH		4-11-77		ROCKWELL INTERNATIONAL			
CHECKED BY						ATOMIC INTERNATIONAL DIVISION			
APPROVED BY						ERDA CONTRACT E (20-2)-3535			
REMOVED BY						ROCKWELL INTERNATIONAL			
REMOVED BY						GOLDEN, COLORADO 80401			
REMOVED BY						EQUIPMENT FLOW SHEET & MATERIAL BALANCE			
REMOVED BY						Pu(III) OXALATE PROCESS			
REMOVED BY						SIZE			
REMOVED BY						DRAWING NUMBER			
REMOVED BY						ISSUE			
REMOVED BY						SHEET			
REMOVED BY						D			
REMOVED BY						A 3 of 4			

D-11A,B&C
DISTILLATION COLUMN
SST, 5" Ø, HEIGHT
ADEQUATE TO GIVE
5 THEORETICAL PLATES,
PACKED WITH PALL
RINGS OR SIMILAR
PACKING

E-5A,B&C
CONDENSER
SST, SHELL & TUBE,
DUTY=300,000 BTU/HR

D-12A,B&C
CONDENSER DRUM
SST, 5" Ø, 10L CAP

P-9A,B&C
CONDENSER PUMP
SST, 0.7 GPM

E-6A,B&C
REBOILER
SST, SHELL & TUBE
DUTY=350,000 BTU/HR

P-8A,B&C
BOTTOMS PUMP
SST, 0.2 GPM

E-7
BOTTOMS COOLER
SST, DOUBLE PIPE
HEAT EXCHANGER,
DUTY=6,000 BTU/HR

D-13A
DISTILLATE STORAGE
SST, FILLED WITH
BORON-GLASS RASCHIG
RINGS, 2000 L CAP

P-10A&B
WASTE PUMP
SST, 16 GPM

STREAM	141	142	143	144	145	146	147														
GMS/HR COMPONENT																					
Pu(NO ₃) ₃	94		95																		
Pu ₂ (C ₂ O ₄)·10H ₂ O																					
H ₂ O	175,473	158,910	15,757	8,172	44,461#/HR																
HNO ₃	56,743	5,935	15,139	305																	
N ₂ H ₄																					
H ₂ C ₂ O ₄	3,995																				
H ₂ C ₂ O ₄	4,116																				
GASEOUS REACTION PRODUCTS (N ₂ O, N ₂ , CO, CO ₂ , NO ₂)				35,108																	
PuO ₂																					
AIR																					
NONVOLATILE IMPURITIES																					
STEAM						999#/HR															
NaNO ₂ or NaNO ₃	138		138																		
TOTAL GMS/HR	239,561	164,845	31,129	43,585	44,461#/HR	999#/HR															
Pu, GMS/L	0.25		2.2																		
FLOW, L/HR	212	165	23.9	33,666																	
PRESS, PSIA	PUMP	PUMP	PUMP	STD																	
TEMP, °C	AMB	AMB	40	STD																	
MOLARITY	0.22 H ₂ C ₂ O ₄		10 HNO ₃																		
BATCH QUANTITY																					
PHASE	LIQUID	LIQUID	LIQUID	VAPOR	LIQUID	VAPOR	LIQUID														

A5. (Continued)

A ORIGINAL ISSUE		4-12-77		AI		ERDA		CLASS		JOB NO.	
DESIGNED		D. NEAL		3-9-77		ROCKWELL INTERNATIONAL		ATOMIC INTERNATIONAL DIVISION		GOLDEN, COLORADO	
DRAWN		S. HATCH		4-12-77		ROCKWELL INTERNATIONAL		ATOMIC INTERNATIONAL DIVISION		GOLDEN, COLORADO	
CHECKED						ROCKWELL INTERNATIONAL		ATOMIC INTERNATIONAL DIVISION		GOLDEN, COLORADO	
APPROVED						ROCKWELL INTERNATIONAL		ATOMIC INTERNATIONAL DIVISION		GOLDEN, COLORADO	
SUBMITTED						ROCKWELL INTERNATIONAL		ATOMIC INTERNATIONAL DIVISION		GOLDEN, COLORADO	
APPROVED						ROCKWELL INTERNATIONAL		ATOMIC INTERNATIONAL DIVISION		GOLDEN, COLORADO	
APPROVED						ROCKWELL INTERNATIONAL		ATOMIC INTERNATIONAL DIVISION		GOLDEN, COLORADO	
SCALE		D		A		4		4			

DIRECT DENITRATION (BATCH)

STREAM	100	101	102	103	104	111	112	105	116	117	118			
GMS/HR COMPONENT														
Pu (NO ₃) ₄	8,489													
H ₂ O	15,214		15,214	466	14,748			466						
HNO ₃	3,156		3,156		3,156									
URANIUM	42	42												
SULFUR	4	4												
HALIDES (F & Cl)	.6	.6												
METAL IONS	42	42												
NO ₂			2,721	2,721				2,721						
NO			313	313				313						
O ₂			724	724				724						
ROOM AIR			25,338	25,338				45,746	25,338	10,988	10,988			
Pu O ₂		4,731												
CHWS						1400#/HR	7000#/HR							
TOTAL GMS/HR	26,948	4,820	47,466	29,562	17,904	1400#/HR	7000#/HR	49,970	25,338	10,988	10,988			
Pu, GMS/L	250													
FLOW, L/HR	16.7				16.3	2.8 GPM	14 GPM		19,592	8,496	8,496			
PRESS, PSIA	GRAVITY FLOW		SYSTEM	SYSTEM	GRAVITY FLOW	SYSTEM	SYSTEM	SYSTEM	SYSTEM	SYSTEM	SYSTEM			
TEMP, °C	AMB	AMB-400	AMB-300	AMB	AMB	15°	15°	AMB	AMB	AMB	AMB			
MOLARITY	3-HNO ₃					3-HNO ₃								
PHASE	LIQUID	SOLID	GAS	GAS	LIQUID	LIQUID	LIQUID	GAS	GAS	GAS	GAS			

NOTES:

1. STREAM FLOW RATES GIVEN ARE FOR THE TOTAL PLANT THROUGHPUT. THROUGHPUT FOR EQUIPMENT SPECIFIED IN PARALLEL IS EQUAL TO THE TOTAL PLANT THROUGHPUT DIVIDED BY THE NUMBER OF UNITS IN PARALLEL.
2. UNLESS OTHERWISE SPECIFIED GEOMETRICALLY SAFE SLAB TANKS INSIDE WIDTH & HEIGHT SHALL BE STANDARDIZED TO 4" X 48" RESPECTIVELY, WITH TANK LENGTH LEFT AS A VARIABLE TO MEET VOLUME REQUIREMENTS, OTHER GEOMETRICALLY SAFE TANKS, REACTORS, & HEAT EXCHANGERS SHALL BE 5" ID CYLINDRICAL VESSELS OF VARIABLE LENGTH.
3. GAS VOLUME FLOW RATES ARE GIVEN AT S.T.P.
4. WHERE NOTED RASCHIG RING (BORON GLASS) PACKED TANKS OF EQUAL NET VOLUME MAY BE SUBSTITUTED FOR TANKS SPECIFIED GEOMETRICALLY SAFE.
5. ALL ROOM AIR DRAWN THROUGH HOOD, SIZING SCREEN (ME-4) IS FILTERED BY FL-2.

A6. (Continued)

A ORIGINAL ISSUE		2-7-77		A1		ERDA CLASS		JOB NO.	
ISSUE		DATE		BY		DATE		U.S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION	
TOLERANCES		DESIGNED		W. SPERRY		2-2-77		ROCKY FLATS AREA OFFICE	
FRAC. & ANG. & DEC. & UNLESS NOTED OTHERWISE		DRAWN		S. HATCH		2-7-77		GOLDEN, COLORADO	
REMOVE BUBBLES AND SHARP EDGES		CHECKED						ROCKWELL INTERNATIONAL	
NEXT ASSEMBLY		APPROVED						ATOMIC INTERNATIONAL DIVISION	
								ERDA CONTRACT E (29-2)-3533	
								ROCKY FLATS PLANT	
								GOLDEN, COLORADO 80401	
								FLOW SHEET & MATERIAL BALANCE	
								BATCH CALCINER	
								CONVERSION OF Pu(NO ₃) ₄ TO PuO ₂	
								SIZE	
								DRAWING NUMBER	
								ISSUE	
								SHEET	
								D	
								A 1 2

STREAM COMPONENT	105	106	107	108	109	110	113	114	115	104										
Pu O ₂																				
H ₂ O	466	5,505	20,253	18,877	1,376	546			5,585	14,748										
HNO ₃			3,156	2,191	965					3,156										
URANUM																				
SULFUR																				
HALIDES (F & Cl)																				
METAL IONS																				
NO ₂	2,721					2,721														
NO	313					313														
O ₂	724					724														
ROOM AIR	45,746					45,746														
STEAM																				
CHWS							5500#/HR													
TOTAL GMS/HR	49,970	5,505	23,409	21,068	2,341	50,050	5500#/HR	56#/HR	5,585	17,904										
Pu, GMS/L																				
FLOW, L/HR		5.5	21.5	19.7	1.9		11GPM		.02GPM	16.3										
PRESS, PSIA	SYSTEM	GRAVITY FLOW	SYSTEM	SYSTEM	SYSTEM	SYSTEM	SYSTEM	100		GRAVITY FLOW										
TEMP °C	AMB	16°	AMB	90°	16°	15°			AMB	AMB										
MOLARITY			2.3-HNO ₃	1.8-HNO ₃	8.2-HNO ₃					3-HNO ₃										
PHASE	GAS	LIQUID	LIQUID	LIQUID	LIQUID	GAS	LIQUID	VAPOR	LIQUID	LIQUID										

A6. (Continued)

A ORIGINAL ISSUE		2-9-77		2											
ISSUE		DATE		AI		ERDA		CLASS		JOB NO.					
TOLERANCES		DESIGNED		BY		DATE		U.S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION		ROCKY FLATS AREA OFFICE		GOLDEN, COLORADO			
FRAC ±		DRAWN		W. SPERRY		2-2-77		ROCKWELL INTERNATIONAL		ATOMIC INTERNATIONAL DIVISION		ERDA CONTRACT E (20-2)-3533			
ANG ±		CHECKED		S. HATCH		2-8-77		ROCKY FLATS PLANT		GOLDEN, COLORADO 80401					
DEC ±		APPROVED						FLOW SHEET & MATERIAL BALANCE		BATCH CALCINER					
UNLESS NOTED OTHERWISE		REMOVE BURRS AND SHARP EDGES						WASTE STREAMS							
NEXT ASSEMBLY		SUBMITTED						SIZE		DRAWING NUMBER		ISSUE		SHEET	
		APPROVED						D				A 2-2			
SCALE		APPROVED													
		ERDA

STREAM	100	101	102	103	104	105	108	111	112	115	146		
GMS/HR COMPONENT													
Pu(NO ₃) ₄	8,489	8,589		300	300		100						
H ₂ O	15,214	121,896			12,038,200		105,682	120,672	2,038,200	25,200			
HNO ₃	3,156	7,938		16,723	16,278	5,574	4,782		5,129				
URANIUM	42	42						42					
SULFUR	4	4						4					
HALIDES	.6	.6						.6					
METAL IONS	42	42						42					
PuO ₂ · HNO ₃ · 2H ₂ O								6,301	1,316				
n-HEXANOL				4,988,464		4,988,464							
COOLING WATER													
STEAM											400#/HR		
TOTAL GMS/HR	26,947	138,511		5,005,487	12,054,777	4,994,038	110,564	127,061	2,043,329	26,516	400#/HR		
Pu, GMS/L	250	.34		2.5X10 ⁻²	1.2X10 ⁻²		.44	33.8		33.8			
FLOW, L/HR	16.7	125.7	2,412.8	6.032	12,055	6.032	110.5	120.6	12,043	25.2			
PRESS. PSIA	SYSTEM	SYSTEM	SYSTEM	SYSTEM	SYSTEM	SYSTEM	SYSTEM	SYSTEM	SYSTEM	SYSTEM	100		
TEMP °C	AMB.	AMB.	TO 100°C	AMB.	TO 100°C	AMB.	AMB.	AMB.	AMB.	AMB.			
MOLARITY				.02 HNO ₃	.02 HNO ₃	.72 HNO ₃			.007 HNO ₃				
PHASE	LIQUID	LIQUID	LIQUID	LIQUID	LIQUID	LIQUID	LIQUID	LIQUID	LIQUID	LIQUID	VAPOR		

- NOTES:
1. STREAM FLOW RATES GIVEN ARE FOR THE TOTAL PLANT THROUGHPUT. THROUGHPUT FOR EQUIPMENT SPECIFIED IN PARALLEL IS EQUAL TO THE TOTAL PLANT THROUGHPUT DIVIDED BY THE NUMBER OF UNITS IN PARALLEL.
 2. UNLESS OTHERWISE SPECIFIED GEOMETRICALLY SAFE SLAB TANKS INSIDE WIDTH & HEIGHT SHALL BE STANDARDIZED TO 4" X 48" RESPECTIVELY, WITH TANK LENGTH LEFT AS A VARIABLE TO MEET VOLUME REQUIREMENTS. OTHER GEOMETRICALLY SAFE TANKS, REACTORS, & HEAT EXCHANGERS SHALL BE 5" ID CYLINDRICAL VESSELS OF VARIABLE LENGTH.
 3. GAS VOLUME FLOW RATES ARE GIVEN AT S.T.P.
 4. WHERE NOTED RASCHIG RING (BORON GLASS) PACKED TANKS OF EQUAL NET VOLUME MAY BE SUBSTITUTED FOR TANKS SPECIFIED GEOMETRICALLY SAFE.

A7. (Continued)

ORIGINAL ISSUE		1-26-77		DATE		BY		DATE		U.S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION	
DESIGNED		W. SPERRY		1-3-77		DRAWN		S. HATCH		1-26-77	
CHECKED						APPROVED					
SUBMITTED						SCALE		APPROVED		ERDA	
ERDA						D		A		1 of 4	

ROCKWELL INTERNATIONAL
ATOMIC INTERNATIONAL DIVISION
ERDA CONTRACT E (20-2)-3833
ROCKY PLATS PLANT GOLDEN, COLORADO 80401
FLOW SHEET & MATERIAL BALANCE
SOL-GEL PROCESS FOR
CONVERSION OF Pu(NO₃)₄ TO PuO₂

STREAM GMS/HR COMPONENT	106	107	108	109	110	112	113	114	118	131	136	137	138	139	142	143	144	145	147	150	153	104	
Pu(NO ₃) ₄		300	100	100	200	12,038,200	120,382	65,555	VAPOR 121,380	7,216	VAPOR 1,350	2,773	118,587	232,149	6,704	28,672	260,913	26,091				12,038,200	
H ₂ O	11,917,818	120,382	105,682	40,127	80,255	12,038,200	120,382	65,555						7,432								16,278	
HNO ₃	5,129	11,148	4,782	3,716	7,432	5,129		1,065															
ISOAMYL ALCOHOL										144				144									
n-HEXANOL																							
STEAM																			33,000#/HR				
CHWS																				5,000,000 #/HR	30,000#/HR		
N ₂									6,052			6,052			6,052								
ROOM AIR									166,440			61,225	166,440		227,665								
NO ₂									562			63	562		625								
NO									92			10	92		102								
O ₂									171			19	171		190								
TOTAL GMS/HR	11,922,947	131,830	110,564	43,944	87,887	12,043,329	120,382	66,620	294,678	7,361	62,666	176,091	118,587	239,926	241,338	28,672	260,913	26,091	33,000#/HR	5,000,000 #/HR	30,000#/HR	12,054,777	
Pu, GMS/L		1.17	.44	1.2	1.2									.4								1.2 X 10 ⁻²	
FLOW, L/HR	11,917.8	125.5	110.5	41.8	83.5	12,043	120.4	66.6	285,362	7.2		136,015	118.6	239.7	186,412.9	28	260	26		6,000 GPM	60 GPM	12,055	
PRESS, PSIA	SYSTEM	SYSTEM	SYSTEM	SYSTEM	SYSTEM	SYSTEM	SYSTEM	SYSTEM	SYSTEM	SYSTEM	SYSTEM	SYSTEM	SYSTEM	SYSTEM	SYSTEM	SYSTEM	SYSTEM	SYSTEM	SYSTEM	SYSTEM	SYSTEM	SYSTEM	
TEMP, °C	AMB	100°C	AMB	AMB	100°C	AMB	AMB	100°C	AMB	137°C	AMB	AMB	AMB	31	AMB	31	31					AMB	
MOLARITY	.007HNO ₃	.147HNO ₃	.72HNO ₃	.147HNO ₃	.147HNO ₃	.007HNO ₃		.26HNO ₃						.5HNO ₃								.02HNO ₃	
PHASE	LIQUID	LIQUID	LIQUID	LIQUID	LIQUID	LIQUID	LIQUID	LIQUID	GAS	LIQUID	GAS	GAS	LIQUID	LIQUID	GAS	LIQUID	LIQUID	LIQUID	VAPOR	LIQUID	LIQUID	LIQUID	

SEE NOTES SHEET (1)

A7. (Continued)

A ORIGINAL ISSUE		1-28-77		DATE		A1		ERDA CLASS		JOB NO.	
DESIGNED BY W. SPERRY		1-3-77		ROCKWELL INTERNATIONAL		ATOMIC INTERNATIONAL DIVISION		ERDA CONTRACT # (20-21-3533)		GOLDEN, COLORADO 80401	
DRAWN BY S. HATCH		1-28-77		ROCKWELL INTERNATIONAL		ATOMIC INTERNATIONAL DIVISION		ERDA CONTRACT # (20-21-3533)		GOLDEN, COLORADO 80401	
CHECKED				ROCKWELL INTERNATIONAL		ATOMIC INTERNATIONAL DIVISION		ERDA CONTRACT # (20-21-3533)		GOLDEN, COLORADO 80401	
APPROVED				ROCKWELL INTERNATIONAL		ATOMIC INTERNATIONAL DIVISION		ERDA CONTRACT # (20-21-3533)		GOLDEN, COLORADO 80401	
SUBMITTED				ROCKWELL INTERNATIONAL		ATOMIC INTERNATIONAL DIVISION		ERDA CONTRACT # (20-21-3533)		GOLDEN, COLORADO 80401	
APPROVED				ROCKWELL INTERNATIONAL		ATOMIC INTERNATIONAL DIVISION		ERDA CONTRACT # (20-21-3533)		GOLDEN, COLORADO 80401	
APPROVED				ROCKWELL INTERNATIONAL		ATOMIC INTERNATIONAL DIVISION		ERDA CONTRACT # (20-21-3533)		GOLDEN, COLORADO 80401	
SCALE				SIZE		DRAWING NUMBER		ISSUE		SHEET	
D				D		A		3		4	

PART	QTY	DESCRIPTION	MATERIAL
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D-19
WASTE STORAGE TANK
SST-GEOMETRICALLY SAFE
375 LITER CAPACITY "SLAB TANK"
6 TANK REQ.
SEE NOTE (4)

P-21 <u>TRANSFER PUMP</u> SST-CANNED PUMP 2 GPM	P-22 <u>RECYCLE PUMP</u> SST-CANNED PUMP 1 GPM
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D-20
EVAPORATOR
SST-GEOMETRICALLY SAFE
250 L/HR CAPACITY

D-21
CONDENSER SUMP TANK
SST-GEOMETRICALLY SAFE
20 LITER CAPACITY

E-10
CONDENSER
SST- SHELL & TUBE
DUTY: 1×10^6 BTU/HR

E-11
REBOILER
SST-SHELL & TUBE
DUTY: 1×10^6 BTU/HR

D-22
CONDENSATE STORAGE TANK
SST-GEOMETRICALLY SAFE
375 LITER CAPACITY
6 TANK REQ.
SEE NOTE(4)

D-23
RECYCLE STORAGE TANK
SST-GEOMETRICALLY SAFE
375 LITER CAPACITY

P-18
TRANSFER PUMP
SST-CANNED PUMP

P-19
TRANSFER & CIRCULATION PUMP
SST-CANNED PUMP
10 GPM

P-20
TRANSFER PUMP
SST-CANNED PUMP

[illegible]

SEE NOTES SHEET (I)

A7. (Continued)

A ORIGINAL ISSUE		2-2-77		02					
DATE	DESCRIPTION	DATE	AI		ERDA	CLASS	JOB NO.		
TOLERANCES		U.S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION							
FRAC. ±	DESIGNED	BY	DATE		ROCKY FLATS AREA OFFICE				
ANG. ±	W.SPERRY		1-3-77		GOLDEN, COLORADO				
DEC. ±	DRAWN		S.MATCH		ROCKWELL INTERNATIONAL				
UNLTD. NOTES	CHECKED		2-2-77		ATOMICS INTERNATIONAL DIVISION				
OTHERWISE	APPROVED				ERDA CONTRACT E (28-2)-3533				
REMOVE BURRS					ROCKY FLATS PLANT				
AND SHARP EDGES					GOLDEN, COLORADO 80400				
NEXT ASSEMBLY					FLOW SHEET & MATERIAL BALANCE				
					SOL-GEL PROCESS				
					WASTE STREAMS				
	SUBMITTED		SIZE	DRAWING NUMBER		ISSUE	SHEET		
SCALE	APPROVED AI		D						
✓	APPROVED ERDA						A 4 of 4		

PEROXIDE PRECIPITATION