0029025

PROCESS FLOWSHEET DOCUMENT

REMOTE MECHANICAL C (RMC) LINE

PLUTONIUM FINISHING PLANT

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PFP PROCESS CONTROL

JUL 1993
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Release Date	Expiration	Document No.	Rev/Mod	Page
06/18/91	----------	PFD-Z-190-00002	C-0	1 of 20

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1.0 INTRODUCTION

This document describes the conversion of plutonium nitrate solution to plutonium oxide powder. The process is carried out in the Remote Mechanical C (RMC) Line of the Plutonium Finishing Plant (PFP/234-5Z/200W). Included in the flowsheet are a process schematic/material balance, process description, troubleshooting guides, safety concerns and equipment description. A list of references is also included to provide more detailed information about the process.

2.0 PROCESS SUMMARY

The plutonium nitrate solution used as feed for the RMC line is received in Product Receiver (PR) cans and loaded into glovebox tanks form the PR cans. Appropriate chemicals are added to the solution to achieve the optimum plutonium concentration, valence, and nitric acid molarity (Figure 1). The resulting feed solution is reacted with oxalic acid in a continuous process to form a plutonium oxalate precipitate. This slurry is then vacuum filtered. The process up to this point is referred to as Task I.

Task II consists of calcination and filtrate handling. The plutonium oxalate solids from the vacuum drum filter enter the first stage calciner where the plutonium oxalate conversion to plutonium oxide is started. In the fluorinator (modified to a second stage calciner)[1], the oxide produced in the first stage calciner is contacted further with air at an elevated temperature to ensure the formation of plutonium oxide.

Task III of the process has been discontinued, plutonium metal production . Task III has been up-dated to support the stabilization of plutonium nitrate. Oxide handling now makes up Task III. Blending, screening, sampling, and canning are the major operations in Task III to safely store oxide product.

Filtrate from the precipitation process is mixed with potassium permanganate to partially neutralize excess oxalic acid. This solution is then sent to the filtrate evaporator (TK-21) in the Plutonium Reclamation Facility (PRF), 236-Z.

*1--The fluorinator has been modified to act as a second stage calciner.

3.0 PROCESS DESCRIPTION

3.1 Feed Preparation

The plutonium nitrate solution used as feed for the RMC line is received in PR cans, FL-10, L-10, and 10L containers (8-9 liters each). The feed solution is loaded into three batch tanks in glovebox HC-227S. After each can is emptied, the can is rinsed with nitric acid solution. The rinse solution is also transferred to the batch tanks. The batch, consisting of 100-120 liters of solution, is then recirculated to provide adequate blending and sampled for feed adjustment calculations. When the solution is within process parameters, it is transferred to HC-4 for feed staging.

The plutonium nitrate solution is vacuum transferred in approximately 10 liter draws to the Pre-Reduction Tank (PRT) in HC-7C. Dilute (2 Molar) or concentrated (12 Molar) nitric acid is added to achieve the desired acid and plutonium concentrations and hydrogen peroxide is added to achieve the proper valence (i.e., to convert Pu(VI) and Pu(III) to Pu(IV)). The peroxide solution is added slowly to reduce the rate of foaming caused by the production of oxygen. After acid and valence adjustments, the batch is gravity transferred to the Transfer Head Tank (THT). From the THT, the adjusted batch enters the reactor (RCTR) in HC-9B in continuous flow for the precipitation process.

3.2 Precipitation/Filtration

Plutonium nitrate feed is continuously pumped from the THT to the reactor where it is reacted with oxalic acid. The oxalic acid flow is controlled to provide a specified ratio to the feed flow based on desired H^+ and oxalic acid concentration in the reactor overflow. A plutonium oxalate slurry is formed by the reaction (section 4.2) and overflows to the Vacuum Drum Filter (VDF). Here, the plutonium oxalate solids are separated from the filtrate. Vacuum is supplied through the Vacuum Receiver Tank (VRT) where 17"-20" Hg vacuum is maintained. The plutonium oxalate solids are picked up on the rotating drum of the VDF and washed with a 2.0 M nitric acid - 0.05 M oxalic acid solution to remove impurities. The solids are cut off the drum by a adjustable doctor blade and discharged into the first stage calciner (CLNR).

3.3 Calcination

Plutonium oxalate solids are continuously fed into the first stage calciner which is operated at a temperature of about 425 °C. It is equipped with a screw that moves the solids down the calciner, through three increasing temperature stages, in countercurrent flow with air (the source of the oxygen). The speed of the screw is set to provide adequate residence time in the calciner. The plutonium oxalate solids decompose to plutonium oxide. The solids drop into the second stage calciner through a gravity fed tube/chute. The oxide conversion is continued through the second stage calciner to maximize conversion of the oxalate to plutonium oxide.

The second stage calciner is set on an angle and vibrated at specific intervals to provide the motive force through the tube. The vibration causes the powder to travel downhill in the secondary calciner, contacting plutonium oxide further with air (the source of O_2) in a countercurrent flow. This ensures the plutonium oxalate is completely converted to oxide form. The plutonium oxide is then collected in a powder pan, weighed in glovebox HC-10 and stored in HC-11.

3.4 Filtrate Handling

The filtrate from the VDF is received in the Vacuum Receiver Tank (VRT) located in the bottom of glovebox HC-9B. It is then continuously pumped to the Filtrate Catch Tank-Filtrate Kill Tank (FKT-FCT), a U-shaped tank in HC-7C. Potassium permanganate ($KMnO_4$) solution is continuously added to the FKT to initiate decomposition of the excess oxalic acid. The $KMnO_4$ flow is adjusted so that the top one-half to one inch of solution has a purplish tint. The solution in the FCT is overflowed to the Filtrate Storage Tank (FST). Periodically, the filtrate is sent to the evaporator in PRF where decomposition of oxalic acid is completed and the solution volume is reduced.

3.5 Offgas Treatment

Offgases from the calciners, which contain air, CO_2, HNO_3, and H_2O are vacuum transferred through three parallel filter elements into the Condensate Receiver Tank (CRT). In the CRT, the offgas is bubbled through concentrated nitric acid to remove condensibles and very fine plutonium oxide particles that pass through the filter elements. The cleaned offgas is pulled through the 26" process vacuum header to sintered metal,

backflushable filters to remove contamination that may be present as mists or aerosols and through HEPA filters prior to being sent to the 291-Z stack.

4.0 PROCESS TECHNOLOGY

4.1 Plutonium Valence Adjustment

The plutonium contained in $Pu(NO_3)_4$ solution usually exists in the Pu(IV) state. However, under certain conditions, quantities of Pu(III) and Pu(VI) can also be present. The Pu(III) state does not exist in solutions with greater than 4 M HNO_3 concentrations and when present does not significantly affect the precipitation process or increase waste losses. However, the Pu(VI) valence state, which exists as the plutonyl ion, PuO_2^{++}, or plutonyl oxalate, is more soluble than Pu(IV). Therefore, when Pu(VI) exists, high Pu losses to the filtrate result.

Hydrogen peroxide oxidizes Pu(III) and reduces Pu(VI) to the Pu(IV) state by the following reactions:

$$2Pu(NO_3)_3 + 2HNO_3 + H_2O_2 \text{ -----> } 2Pu(NO_3)_4 + 2H_2O$$

$$PuO_2(NO_3)_2 + 2HNO_3 + H_2O_2 \text{ -----> } Pu(NO_3)_4 + 2H_2O + O_2$$

During the reduction reaction, the oxygen produced causes foaming. To reduce foaming, the peroxide solution is added in small batches at intervals. Excess peroxide is used because of a competing side reactions with iron.

Addition of hydrogen peroxide requires a digestion time of at least 30 minutes. Digestion times of less than thirty minutes may result in incomplete reactions with a reduction in particle size during the precipitation step and higher filtrate losses.

4.2 Precipitation/Filtration

The precipitation of plutonium nitrate with addition of oxalic acid takes place according to the reaction:

$$Pu(NO_3)_4 + 2H_2C_2O_4 + 6H_2O \text{ ----> } Pu(C_2O_4)_2 \cdot 6H_2O + 4HNO_3$$

Several parameters in the reactor are important to achieving proper precipitation and reducing Pu losses. These include: (1) H^+ concentration, (2) excess oxalic concentration, (3) agitation speed, (4) residence time and (5) temperature.

The H^+ concentration in the reactor overflow should be 2.5 ± 0.5 M. At $[H^+]$ below 1.5 M, coprecipitation of impurities is favored and particles are too finely divided for filtration. With $[H^+]$ greater than 4.5 M, plutonium (IV) oxalate solubility is high and the precipitate is a thixotropic gel which is difficult to filter and dry.

The optimum excess oxalic acid concentration in the RCTR (reactor) overflow is 0.15 ± 0.05 M. Less than this may result in incomplete reaction of $Pu(NO_3)_4$. A large excess of free oxalic acid increases the solubility of the plutonium oxalate in the filtrate resulting in high Pu losses. It can also interfere with filter cake consistency.The process has run successfully with a target excess oxalic concentration of 0.18 M.

The agitation rate must be fast enough to provide proper mixing and adequate slurry suspension, but excessive stirring results in particles that are too fine and difficult to filter. If the agitator is running too slowly, settling of solids in the reactor may occur.

Feed flows are kept constant to provide a average residence time in the reactor of about 8-10 minutes.

The optimum temperature for the precipitation process is 35-60 °C. Temperatures above 60 °C produce a gelatinous or "gummy" precipitate.

4.3 Calcination

Calcination reaction is as follows:

Calcination:

$$Pu(C_2O_4)_2 \cdot 6H_2O + O_2 \text{ -------> } PuO_2 + 4CO_2 + 6H_2O$$

Thirty pound instrument air provides the source of oxygen to the first stage calciner. Residence time in the first stage calciner is approximately 50 minutes. The temperature of calcination is much more important than residence time (reference 4). Three heaters placed at the inlet, center and outlet maintain the temperature between 400 and 450 °C. The purpose is to produce PuO_2 with a low LOI (Loss-on-Ignition) and a maximum bulk/tap density.

4.4 Filtrate Handling

The filtrate resulting from the precipitation process contains free oxalic acid. Potassium permanganate ($KMnO_4$) is used to partially decompose the acid. The reaction is:

$$2KMnO_4 + 5H_2C_2O_4 + 6HNO_3 \text{ ------> } 2Mn(NO_3)_2 + 2KNO_3 + 8H_2O + 10CO_2$$

The permanganate flow is adjusted to achieve a purplish tint in the top $^1/_2$ - 1 inch of solution in the FKT during addition. This rate of addition is adequate for partial decomposition of about 15% of the oxalic acid. Partial decomposition is required since the PRF filtrate concentrator is not, at times, fully capable of completely breaking down the oxalic acid. Complete decomposition is not desirable since, in the filtrate concentrator, the presence of small amounts of oxalic acid is preferable to nonvolatile potassium salts. Also, $KMnO_4$ addition causes a decrease in HNO_3 concentration so that too much permanganate could cause a CPS violation if the H^+ concentration falls below 1.3 M. Heat and nitric acid in the concentrator-evaporator complete the decomposition of the oxalic acid and provide an approximate 8:1 volume reduction.

Previous campaigns have shown the filtrate evaporator in PRF to be a limiting factor in continuous RMC operations. The percent of oxalic that can be decomposed in the FKT is limited by the volume of solution that can be concentrated in the evaporator (current 1988 flowsheet value is 15% though higher percentages may be desirable). In determining production rates two factors need to be considered: (1) flowrates to the evaporator cannot exceed 40 LPH, (2) while the filtrate from the FST constitutes the majority of liquid in this stream and roughly 1 liter of slurp solution from the ACT (generated from floor slurps, and solution from vacuum traps and demisters). Floor slurps from PRF are also sent to the evaporator.

5.0 PROCESS CONTROL

Detailed process information for the RMC Line is described in Remote Mechanical C (RMC) Line FY-92 Process Control Plan (reference 8).

5.1 Programmable Controller (PC) Loops

Thirteen variables are controlled by a programmable controller (PC). These are listed below.

Loop Number	Variable
1	Second Stage Calciner Inlet Temperature
2	Second Stage Calciner Center Temperature
3	Second Stage Calciner Outlet Temperature
4	First Stage Calciner Inlet Temperature
5	First Stage Calciner Center Temperature
6	Calciner Outlet Temperature
7	Fluorinator Vacuum (INACTIVE)*
8	Second Stage Calciner Air Flow
9	Oxalic Acid Flow
10	Pu Nitrate Feed Flow
11	VRT Vacuum
12	FST Level
13	HA-46 Conductivity (INACTIVE)

* **The fluorinator has been modified for use as a second stage calciner.**

Optimum values for each of the parameters are entered into the PC and can be adjusted if required. The potential for a total of 16 PID loops exists.

5.2 Liquid Level

Liquid level is generally determined by visual observation. Most of the vessels in the nitrate stream are clear glass and have calibration scales (0.25 liter increments) attached. The FST and THT in HC-7C have weight factor instruments; the FST and THT read-out in the RMC control room and are equipped with high and low level alarms. Conductivity elements in vacuum traps alarm when liquid levels are high. Activation of the vacuum trap liquid level alarms automatically close the vacuum supply valves. This is to prevent liquid entry into the 26" vacuum system and possible criticality prevention specification (CPS) violations.

5.3 Fluid and Gas Flows

The plutonium nitrate feed and oxalic acid flow to the reactor are regulated by flow control loops using magnetic flow meters and diaphragm operated valves (DOVs). These stream flows are interlocked such that if the reactor agitation is interrupted, the feed to the reactor is automatically shut off. If the agitator were

inoperable and the feed flow continued, additional, newly formed precipitate would build up in the bottom of the reactor forcing process shutdown and clean out of the reactor solids.

The hydrogen peroxide addition to the Pre-Reduction Tank (PRT) is carried out over a period of time to prevent excess foaming. An adjustable timer allows the addition valve to open for about one second during thirty second intervals until the peroxide addition is complete.

Permanganate addition is manually controlled such that the top $^1/_2$ - 1 inch of solution in the FKT has a purplish tint.

5.4 Temperature

When starting up the process, the first stage calciner and second stage calciner are heated very slowly to avoid thermal shock to equipment. The heating ramp (~1.5 °C/min, maximum) is controlled by the PC.

The temperature of the reactor is not presently controlled but is monitored. The reactor is heated to about 50 °C when solution is not flowing due to the close proximity of the first stage calciner and second stage calciner. During operation about 35 °C is maintained.

The first stage calciner temperature (425°) is extremely important to powder quality and is heated in three zones controlled by the PM-550 Controller. Uneven heating can cause deformation of the calciner tube and screw. The second stage calciner temperature is set to 525°. The heaters on the second stage calciner and first stage calciner have high and low temperature alarms. A high temperature alarm in any zone automatically shuts off all the heaters in all zones.

5.5 Oxide Product Characteristics

Oxide product characteristics are controlled after calcination of the precipitate by monitoring several variables: humidity, oxide particle sizing, V-blend time, and LOI/Isotopic results.

The glovebox humidity is monitored on a continuous basis using a real time hygrometer system. The humidity must be kept at -6°F or less, since the plutonium oxide is hygroscopic. The adsorption of water creates an oxide which is subject to radiolysis. The radiolysis causes

gases to be generated in the storage containers making it unstable for long term storage.

The particle size of the plutonium oxide is controlled by running the oxide through a sieve shaker prior to blending in the V-blender. The oxide is vibrated through a 170 mesh screen. The screen used allows properly calcined product to be obtained. Material collected by the screen (particle size greater than 170 mesh) is considered uncalcined, ground in a motar and pestle to break up the large chunks, and recycled to the calciners.

Oxide is placed in the V-blender after it has been properly screened. The V-blender is used to produce a homogeneous plutonium oxide. Experience has shown that mixing for 5 minutes was sufficient.

Samples obtained from the V-blender are analyzed using LOI (Loss-on-Ignition). Oxide from the V-blender is ignited and if the weight loss is less than 1.0 percent the oxide from the V-blender is canned and sent to storage. A weight loss greater than 1.0 percent requires the oxide to be recycled to the calciners.

6.0 OFF-STANDARD CONDITIONS

Discussed below are the most frequently occurring off-standard conditions. Details of troubleshooting can be found in Remote Mechanical C Line Troubleshooting Guide, reference 2.

6.1 Excess Foaming in Pre-Reduction Tank (PRT)

Excess foaming in the PRT may occur during H_2O_2 addition which can result in solution flow to the E-4 vent trap inside HC-7C. It is caused by a rate of addition of hydrogen peroxide that is too fast, which generates too much oxygen and is probably due to a malfunction of the addition timer or valve, or from excess iron in the feed.

6.2 Rising Vacuum Receiver Tank (VRT) liquid level

A rising liquid level in the VRT may be caused by a partial plug or failure of the VRT pump. The VRT will overflow to the vacuum trap in HC-7. If solution level rises to within 3 inches of the top of the VRT, the feed and oxalic acid addition must be stopped until the problem is resolved.

6.3 High Pu Concentration in the Filtrate

This is evidenced by tan to green color or the observation of solids in the VRT and confirmed by sampling. It may be caused by a hole in the filter cloth, high H^+ concentration or improper oxalic addition. High concentration of Pu(VI) in the filtrate is evidenced by an orange color.

6.4 Increase in Overflow Tank Liquid Level

The vacuum drum filter pan overflows to the Overflow Tank (OT) which overflows to the floor of HC-9B. High liquid level may be caused by VRT vacuum problems, a feed flow rate that is too high or filter cake that is gummy or "glazed" (see section 4.2 for causes of irregular filter cake).

7.0 EQUIPMENT DESCRIPTION

Table 1 provides a description of process vessels located in RMC gloveboxes. All cylindrical vessels and tanks within gloveboxes (i.e., those that have potential for containing fissile material) are 6 inches or less in diameter to ensure a geometrically favorable configuration. Most tanks are glass to provide visibility for the presence of solids and liquid level measurement.

Gloveboxes are free-standing and many are accessible from all sides. Most operational sides of the gloveboxes are layered with lead glass or have water filled panels to provide shielding. Gloves used are thick enough to resist puncturing but not so thick that they are cumbersome to work in. They are made of durable Hypalon and some are lead lined for shielding.

Since most process streams contain nitric acid, stainless steel (304, 304L) is used for piping and equipment due to its resistance to corrosion. The HF used in past RMC campaigns, required pipes made of Teflon, Hastelloy or Kynar for reduced corrosion.The second stage calciner is lined with a platinum-iridium alloy which is compatible with process solids and vapors.

7.1 Precipitation and Calcination

The reactor vessel is a 13.5 inch length of 6 inch diameter stainless steel. A propeller agitator is used to provide better mixing. The reactor is round bottomed, baffled and made of stainless steel. The overflow pipe to the VDF is 8 $^1/_2$ inches from the bottom. The operating volume of the reactor is 2.71 liters.

The location of the overflow pipe and the volume will remain approximately the same.

The VDF in HC-9B is a rotary drum filter with a drum 11 3/4 inches in diameter and 5 inches in width. It utilizes replaceable woven synthetic fabric filter media and an oscillating paddle (wig-wag) immersed in the slurry to prevent solid settling. A wash distributor is suspended just above the filter drum to allow the filter cake collected on the filter cloth to be washed with oxalic acid. A doctor blade is positioned to scrape all but a thin layer of the cake from the cloth and discharge it to the calciner.

The first stage calciner is a 6 3/4 foot long covered trough 4 inches deep with a round bottom 4 inches in diameter. Material is moved through the first stage calciner by a rotating conveyor screw which extends the full length of the calciner. Heating elements and insulation maintain the desired operating temperature. Offgases from the first stage calciner are drawn through a set of housed filters on the oxalate inlet side of the first stage calciner. The powder leaving the calciner is dropped through a gravity chute to the second stage calciner.

The second stage calciner is an oval shaped tube nominally 2 inches high, 4 inches wide and 5 1/2 feet long. The tube is made of Inconel with a platinum-iridium liner. It is set at an angle of about 10° from the horizontal so that periodic vibration of the tube causes the powder to move through. The ball valve which allowed oxide transfer from the first stage calciner to the second stage calciner was removed. A gravity chute or straight spool was installed. The plutonium oxide is discharge into a powder pan from the second stage calciner. The power pan is gasketed to the second stage calciner. A valve is closed during powder pan exchange which does not allow air into the second stage calciner. Heating elements and insulation maintain the desired operating temperature of the second stage calciner.

Powder pans, PV's, and other tools can be transported and manipulated between each glovebox with conveyors HC-1 and HC-2. Sweep arms are used for moving materials on and off the conveyors. The conveyors provide for minimum manual assistance through the gloves and are controlled from the RMC control room.

Table 1: Glovebox Process Vessel Summary

Vessel	Construction	Nominal Volume (l)
227S:		
Batch Tanks (3)	6" glass X 8′	45
Vacuum Trap	6" glass X 1.5′	8.3
Loadout Tank	6" glass X 2′	11
HC-4:		
Storage Tanks (6)	6" glass X 4′	22
Vacuum Trap	6" glass X 1′	5.5
HC-7:		
Peroxide Measuring Tank	3" sch 40 SSt X 22"	2.5
Pre-Reduction Tank (PRT)	6" glass X 3′	16.5
Transfer Head Tank	6" glass X 3′	16.5
Filtrate Kill Tank/ Filtrate Catch Tank (FKT/FCT)	6" glass X 4′ 4" glass X 3.5′, interconnected	32
Filtrate Storage Tank (FST)	6" glass X 6′	33
Aqueous Collection Tank (ACT)	6" glass X 4′	22
Vacuum Trap (VT) and E-4 Vent Trap	6" glass X 1′	5.5
Flush Tank	6" glass X 1′	5.5
HC-9B:		
Reactor (RCTR)	6" sch 10 SST w/ side overflow	3
Vacuum Receiver Tank (VRT)	6" glass X 2′	11
Condensate Receiver Tank (CRT)	6" glass X 1′	5.5
Overflow Tank (OT)	6" glass X 1′	5.5

8.0 SAFETY

8.1 Hazardous Chemicals

8.1.1 Liquids

Several hazardous liquids (nitric acid, oxalic acid, hydrogen peroxide, and potassium permanganate) are used during RMC operation. The hazardous properties of these chemicals are described in the appropriate Material Safety Data Sheet (MSDS).

8.2 Radiation Exposure

Plutonium oxide, not plutonium metal will be produced during the FY-92 campaign. It must be remembered, potential exists for high neutron dose rates in some regions of the RMC line processing area. Dose rate values are displayed and pencil dosimeters are worn by personnel working for extended periods of time in these areas. The principles of ALARA (As Low As Reasonably Achievable) are applied at all times. These consist of minimizing time spent in high dose areas while maximizing shielding and distance.

8.3 Criticality

The routine handling of greater than kilogram quantities of plutonium compounds on the RMC line requires that the operating personnel be adequately trained, conscientiously careful and strictly adhere to the applicable operating Procedures, Criticality Prevention Specifications and hood postings.

9.0 ESSENTIAL MATERIALS

Materials required for operation of the RMC metal line are listed in table 2 along with the applicable material specifications number in the Essential Material Specifications section of Essential Materials Specifications, reference 5.

Table 2: Essential Materials

Essential Material	Essential Material Number
Hydrogen peroxide	EMS-G-132-526
Nitric acid	EMS-G-132-670
Oxalic acid	EMS-G-132-690
Potassium permanganate	EMS-G-132-750
Bottled Air for 2nd stg Calciner	TBD

10.0 FLOW DIAGRAMS AND MATERIAL BALANCE

Figure 1 shows typical volumetric flow rates and concentrations achieved during operation of the RMC line.

The mass balance results in Table 3 are generated using a spreadsheet (Lotus Symphony, Version 2.0, or later, or compatible software).

The spreadsheet requires input defining the feed and chemical make-up stream compositions and the extent of reactions (and physical separation in the VDF).

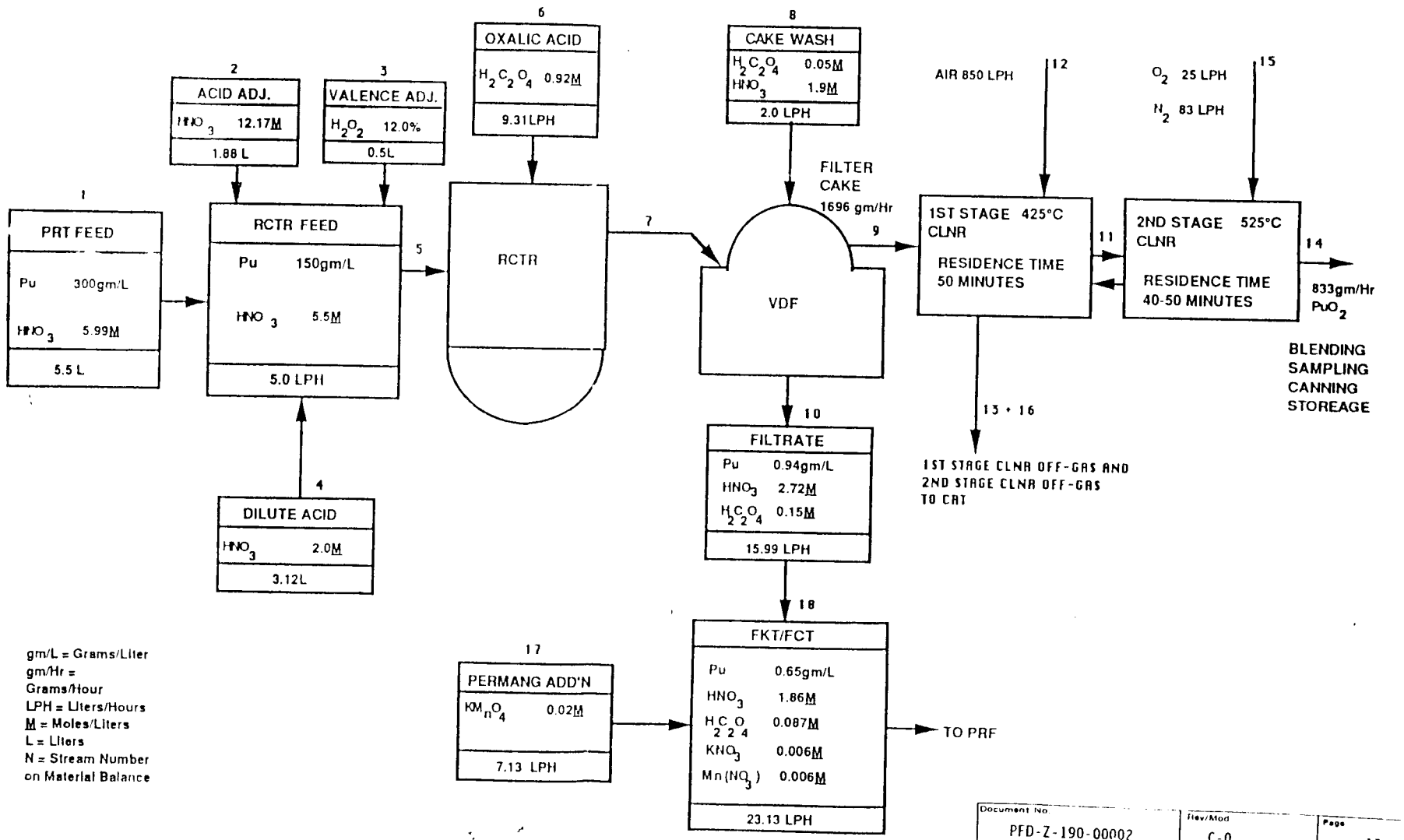
The Table 3 values in the attached spreadsheet printout are reflective of actual operating conditions.

The key assumed parameters are as follows:

- Negligible Pu(VI) in feed and 0.5 L minimum H_2O_2 volume
- 150 g Pu/L feed to RCTR
- 2 % filtrate Pu losses
- 0.18 M $H_2C_2O_4$ in RCTR overflow
- 2.8 M HNO_3 in RCTR overflow
- 100 % conversion to PuO_2
- 15% of $H_2C_2O_4$ is destroyed by $KMnO_4$

Changing the value(s) for input compositions or assumptions produces a new, correct material balance table for these conditions **ONLY IF** the resulting process description is within the envelope of the spreadsheet calculations.

FIGURE 1. RMC OXIDE LINE FLOW DIAGRAM



gm/L = Grams/Liter
gm/Hr = Grams/Hour
LPH = Liters/Hours
M = Moles/Liters
L = Liters
N = Stream Number on Material Balance

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	TABLE I FEED TREATMENT						TABLE II PRECIPITATION			TABLE III FILTRATION			TABLE IV CALCINATION				TABLE V – FILTRATE PROCESSING							
STREAM	1	2	3	3a	4	5	5a	6	7	8	9	10	11	12	13	14	15	16	17	18		19	20
DESCRIPTION	PRT FEED	CONC. ACID	VALENCE ADJUST	Valence Offgas	DILUTE ACID	THT MAKEUP	RCTR FEED	OXALIC ACID	RCTR PRODUCT	CAKE WASH	CLNR FEED	RAW FILTRATE	1st St CLNR	AIR TO 1st Stg	1st Stg OFFGAS	2nd Stg CLNR Prod	AIR TO 2nd Stg	2nd Stg OFFGAS	COMB OG STREAMS	KMnO4 ADD'N	TREATED FILTRATE	PART DEST'D FILTRATE	RE-CYCLE FEED	DISTILLATE WASTE
PHASE	LIQUID	LIQUID	LIQUID	GAS	LIQUID	LIQUID	LIQUID	LIQUID	SLURRY	LIQUID	SOLID	LIQUID	SOLID	GAS	GAS	SOLID	GAS	GAS	GAS	LIQUID	LIQUID		LIQUID	LIQUID
LITERS	5.50	1.88	0.50	-	3.12	11.00	-	-	-	-	-	-	-	-	-	-	-	-		-				
LITERS/HR	-	-	-	-	-	-	5.00	9.31	14.31	2.00	-	15.99	-	850.00	-	-	-	-		7.13	23.12	23.12	2.10	21.02
g Pu/L	300.00	-	-	-	-	150.00	150.00	-	52.42	-	-	0.94	-	-	-	-	-	-		-	0.65		7.14	0.00
Sp G	1.62	1.38	1.04		1.06	1.40	1.40	1.04		1.06	-	1.09	-	-	-	-	-	-		-	1.04		0.973	1.040
COMPONENT (gm per THT Batch)						------>	------>		------>			------>			------>								------>	
Pu	1650	-	-	-	-	1650	750	-	750	-	735	15	735	-	-	735	-	-		-	15	15	15	0
PuO2(NO3)2	318	-	-	-	-		0	-	-	-	-	-	-	-	-	-	-	-		-				
Pu(NO3)4	2971	-	-	-	-	3363	1529	-	0	-	-	0	-	-	-	-	-	-		-	0	30	30	
Pu(C2O4)2 6H2O	-	-	-	-	-	-	-	-	1641	-	1608	33	-	-	-	-	-	-		-	33	1	1	
Pu(C2O4)2 0H2O				-			0						26			1								
PuO2	-	-	-	-		-	-	-	-	-	-	-	817	-	-	833	-	-		-	-			
HNO3	2081	1444	-	-	394	3818	1735	-	2527	240	23	2744	-	-	23	-	-		23	-	2717	2701	888	1724
H2O2	-	-	63	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
H2C2O4	-	-	-	-	-	-	-	771	206	9	1	214	-	-	-	-	-	-	-	-	182	193	2	
KMnO4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	23	-			
O2	-	-	-	42	-	-	-	-	-	-	-	-	-	228	131	-	25	23	155	-	-			
N2	-	-	-	-	-	-	-	-	-	-	-	-	-	777	777	-	83	83	860	-	-			
CO2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	531	-	-	11	542	-	31 (g)			187 (g)
KNO3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	14	14	14	-
Mn(NO3)2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	26	26	26	-
H2O	3562	1146	459	-	2930	8143	3701	8880	12243	1871	64	14050	-	-	397	-	-		397	7112	21172	21178	1085	20144
NO				-			0																	43 (g)
TOTAL	8932	2589	521	42	3324	15324	6965	9651	16617	2120	1697	17040	842	1005	1860	834	108	116	1976	7134	24174	24143	2046	22097

FEED CALCULATIONS:

grams Pu/liter in 227S=	300.00 g/l	* enter
grams Pu(VI)/l in 227S=	35.00 g/l	* enter
[H+] in 227S=	6.00 M	* enter
SpG in 227S=	1.62	* enter
HNO3 supply concentration=	12.20 M	* enter
oxalic supply conc.=	0.92 M	* enter
dilute HNO3 supply conc.=	2 M	* enter
peroxide supply conc.=	3.69 M	* enter
%molar excess H2O2 to Pu(VI)	20 %	* enter
volume PRT=	11.00 l	* enter
grams Pu/liter in PRT =	150.00 g/l	* enter target
RCTR Prod [H+] =	2.80 M	* enter target
RCTR Prod oxalic conc.=	0.16 M	* enter target
[Pu] in 227S=	1.25 M	calculated
% Pu(VI) in 227S=	11.67 %	calculated
[Pu] in THT=	0.63 M	calculated
[H+] in PRT=	5.50 M	calculated

volume Pu feed to PRT=	5.50 l	calculated
volume conc. HNO3 to PRT=	1.88 l	calculated
volume dilute HNO3 to PRT=	3.12 l	calculated
calc'd volume H2O2 to PRT=	0.26 l	Micalculated
actual volume H2O2 to PRT=	0.50 l	toadded, round up to nearest 0.5, 2.0 Max Add'n
ratio of oxalic supply flow/ reactor feed flow, R=	1.86	calculated
grams Pu/liter in reactor overflow=	52.42 g/l	calculated
[Pu] in reactor overflow=	0.22 M	calculated
grams Pu/liter in PRT=	150 g/l	compare to target
RCTR Prod [H+] =	2.80 M	compare to target
RCTR Prod oxalic conc.=	0.16 M	compare to target

ASSUMPTIONS

1st Stg Clnr Pu(C2O4)2 6H2O % Decomp.	98.00	* enter
2nd Stg Clnr Pu(C2O4)2 % Decomp.	98.00	* enter
% solids removal efficiency in VDF=	98.00 %	* enter
% reaction in reactor=	100.00 %	* enter
cake wash flow=	2.000 l/hr	* enter
oxalic conc. in cake wash=	0.050 M	* enter
nitric conc. on cake wash=	1.900 M	* enter
Sp G of nitric adjust=	1.380	* enter
Sp G of peroxide adjust=	1.043	* enter
Sp G of oxalic supply=	1.037	* enter
Sp G of cake wash=	1.060	* enter
reactor feed flow=	5.000 l/hr	* enter
% nitric in wash that goes to CLNR=	9.50 %	* enter
% oxalic in wash to CLNR=	11.00 %	* enter
% water in CLNR feed=	3.80 %	* enter
liters air/hr to CLNR=	850.00 l/hr	* enter
Vol % O2 in gas to 2nd Stg Clnr	21.00	* enter
MW of Dil Gas to 2nd Stg CLNR	28.95	* enter

meas'd dil gas to FLUR	0.5	alpm * enter
PRES of dil gas to FLUR	30	psig * enter
liters dilution gas/m to FLUR=	1.520408	slpm
O2 flowrate	19.15714	slph (@25 C)
N2 flowrate	72.06734	slph (@25 C)
O2 Molar flowrate	0.78	mol O2/hr
N2 Molar flowrate	2.94	mol N2/hr
% oxalic in filtrate converted by permanganate addition=	15.00 %	* enter
permanganate supply conc.=	0.02 M	* enter
Tk-21 CF, Vb/Vf	11.00	* enter
Tk-21 distillate HNO3 M	1.30	* enter
% of H2C2O4 destroyed	99.00	* enter
% of Pu(C2O4)2 destroyed	97.00	* enter

11.0 SUMMARY

The purpose of updating the RMC line process flowsheet document was: (1) to provide a single source of general information as an overview of the RMC process for those with a technical background who are unfamiliar with the process, (2) to create a spreadsheet for the mass balance tables so that results of changes in process operating conditions can be estimated quickly, and (3) to document changes in the process that have occurred or will occur prior to beginning the FY92 campaign.

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