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Page 1

DESIGN AND DEVELOPMENT STUDY
TASK II REPLACEMENT
RM LINE 234-5 BUILDING D. O. 100991

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Verified By G. E. Savely 11-22-94
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Prepared by

J. R. Fritz

June 9, 1955

This document classified
by E. O. Swain

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DESIGN AND DEVELOPMENT STUDY
TASK II REPLACEMENT
RM LINE 234-5 BUILDING D.O. 100991

A. INTRODUCTION

The Dry Chemistry Process (Task II) of the RM Line provides the means for converting plutonium oxalate to plutonium tetrafluoride. This process consists of drying the oxalate cake and then converting to the tetrafluoride by passing HF gas at elevated temperatures through the filtered cake.

Improvement to or replacement of the present Task II system is being investigated because of the high maintenance costs and unreliability of the present system. This study is one of several being conducted under the Chemical Processing and Reduction Design and Development Program for improving Task II operation. This report describes a Task II system using round filter boats and vertical hydrofluorination furnaces.

B. SUMMARY

The general arrangement of the proposed equipment located in Zone 3 of the process area is shown on the attached drawings SK-2-925, SK-2-932, and SK-2-933. Controls for operation of this equipment are located in Zone I opposite the equipment.

The following benefits should result from the installation of a new Task II system.

1. Maintenance costs on the system should be reduced from a 1954 cost of \$70,800/year for present system to \$17,700/year or a reduction of \$53,100/year.
2. Radiation rates should be reduced in (a) Zone 1 from present 2-4 mrem/hr. to less than 1 mrem/hr., (b) Zone 3 passageway from present 15 mrem/hr. to less than 1 mrem/hr., and (c) the furnace hoods from 20-50% over the present system.
3. The capacity of Task II would be increased by 35% when using batch sizes of 600 units/batch. Task I capacity and Task II capacity could be increased by 67% and 125% respectively when using a batch size of 1,000 units/batch. These increases are due to a decreased time cycle in Task II and an increase in filter boat capacity. Present filter boat capacity ranges from 600-850 units depending on bulk density of the plutonium oxalate.

4. The equipment will be more reliable than the present equipment from the standpoint of less maintenance requirements, better furnace seals which should reduce the recycle rate, equipment operation is not entirely dependent on the conveyor operation, and present satisfactory operation of Rocky Flats and Los Alamos vertical HF furnaces.

An installed cost of \$325,000 is required to replace the present Task II system with a vertical furnace type system.

C. DISCUSSION

1. Chemistry of Process

Direct fluorination of dried plutonium (IV) oxalate is the process presently in use in the Task II system. The chemical reactions occurring in this process probably include each of the following: (1)

Oxygen is metered into the HF stream to prevent reduction of the fluoride to PuF_3 by hydrogen normally present in the HF cylinders.

Dried plutonium oxalate contained in a filter boat from Task I is inserted in an HF furnace. The furnace is heated and hydrogen fluoride gas and oxygen are pulled through the filter cake causing the conversion to PuF_4 to take place (see Figure 1 for heating cycle). This process will be used in the vertical HF furnace system.

2. Equipment Description and Operation

The general arrangement of the proposed equipment is shown on the attached drawings SK-2-925, SK-2-932, and SK-2-933. This equipment is located in Zone 3 of the process area. The controls for operation of the equipment are located in Zone 1 opposite the equipment.

The equipment used in this arrangement includes (a) seven vertical HF furnaces, (b) a piping system for supplying and exhausting HF, O_2 , and cooling air for each of the furnaces, (c) round filter boats, (d) hoods constructed similar to ones now in use in Task III, (e) neutron shielding for the HF furnaces, balance, and storage hood, (f) a remote balance similar to one currently in use in Task III, (g) a slat type conveying system including sweep arms and diverters, similar to the one currently in use in Task III, (h) a central hydraulic system for operating the furnace lifts, (i) a storage hood for storing empty filter boats or boats filled with either plutonium oxalate or plutonium tetrafluoride, (j) modifications to the filter boat stations in Task I, and (k) new control desks in

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Zone 1. No changes are being contemplated for the instrumentation being used in the present Task II system.

The vertical HF furnace is composed of a Hastelloy "C" retort, a heating element which is mechanically attached to the retort, and an insulating jacket which surrounds the retort. The retort is designed with rounded corners which should reduce the high stresses caused by thermal shock which has been the cause of failures with the present retorts. The furnace is sealed by raising a gasketed surface against the bottom of the retort. A hydraulic cylinder supplies the force required to make this seal. During the heating cycle, water is circulated through the cooling coils surrounding the retort in order to keep the sealing gasket cool. HF and oxygen are introduced directly into the filter boat which is spring loaded against the bottom surface of the retort. A condenser is provided in the off-gas line so that gases being exhausted from the filter boat will be condensed and be removed as a liquid. To cool the retort after the heating cycle has been completed, cooling air is circulated around the annular space between the retort and the insulating jacket.

The filter boats for this system will be designed for use in Tasks I, II, and III. In order for these filter boats to be used in Task I it will be necessary to modify the Filter Boat Stations to handle round instead of the present rectangular boats. The filter boats will be designed so that they can be used in the L3MD dumper thereby eliminating the need for a Task III powder pan. The filter boat will be fabricated from Hastelloy "C" and will contain a Baker alloy (60% gold, 25% palladium, and 15% platinum) liner plus a 7" diameter x 1/8" thick sintered platinum filter. The filtering area will be increased by two and one-half times over the filtering area of the present boat filters. This increase in filtering area should improve the fluorination of the oxalate powder in Task II as well as decrease the filtering time required in the Task I operation.

Neutron shielding will be provided around and under the vertical HF furnaces as well as around the filter boat storage and balance hoods. This shielding should reduce the radiation exposure rates in Zone 1 and Zone 3 passageway to less than 1 mrem/hr. Present radiation exposure rates are 2-4 mrem/hr. in Zone 1 area and up to 15 mrem/hr. in Zone 3 passageway. (2) This shielding should also reduce the exposure rates to personnel working on or near furnaces by an estimated 20 to 50% over the present system. Radiation exposure rates for regasketing a furnace are 50-mrem/hr. to the body in the present system. (2)

The slat conveyor system is similar to the one currently in use in Task III. The present Task I conveyor system would be lengthened and a lift station would be installed between the Task I and II conveyor systems in order to elevate or lower the pan to or from Task II.

The operation of the Task II system is described below:

Air dried plutonium oxalate contained inside of a filter boat is transferred from the Task I conveyor onto the Task II conveyor where it is swept into an empty furnace station. The boat is lifted into position inside the furnace and a furnace seal is made. The boat is spring loaded against the roof of the furnace. This feature will allow (a) heat from the retort to be conducted down into the boat; therefore, decreasing the heating requirements during the fluorination cycle, (b) the flow of gas to be directed into the oxalate powder where it will do the most good, and (c) a reduction in furnace area exposed to the corrosive action of HF gas. After a seal has been made, the control panel for the furnace is energized, the aspirator and condenser water is turned on, and the pressure control unit is set to maintain a vacuum inside the furnace. The furnace is evacuated by pulling process gas through the filter boat. This gas passes through the condenser, aspirator, and into a contaminated drain. The furnace power is turned on and the furnace time-temperature program control is started (see Figure 1). After the cooling phase of the cycle has been completed the hydraulic ram will be lowered and the boat transferred to the balance hood for weighing. After weighing, the boat can be transferred either to the storage hood or to H-13MD (mixer-dumper hood in Task III) for further processing.

3. Design Improvements With New Task II System

A. Maintenance of Equipment

Maintenance work in the present Task II system cost approximately \$5900/month during 1954. These costs may be generally attributed to corrosion caused by HF gas. This corrosion causes air leakage into the furnace, exhaust line leaks, failures of the retorts, rotameter and valve deterioration, breakdown of the off-gas disposal system, and cracks in the filter boat liner. A breakdown of costs during 1954 is as follows:

Maintenance Costs on Task II Equipment (11 month period)

	<u>Cost</u>
Labor	\$22,737.94
IME	25,006.13
Material	<u>9,263.52</u>
Sub-Total	\$57,007.59 or \$5,182.51/month
<u>Filter Boat Repairs</u>	
Labor	\$3,353.39
IME	3,688.00
Material	<u>1,677.75</u>
Sub-Total	\$8,719.14 or \$726.60/month
Total	\$5,909.11/month

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By replacing the present system with new equipment it is estimated that it would be possible to reduce the maintenance costs by 75%⁽²⁾. These cost reductions could be achieved in the following manner:

1. The equipment is designed so that it is easily accessible to a maintenance man. Glove ports are located on both the front and rear lucite panels and all equipment can be reached from these ports. Wherever possible operating mechanisms such as motors, cylinders, etc. will be located outside the hood. The present equipment is very difficult to maintain because maintenance men can not reach the equipment without using long handled wrenches, etc.
2. The equipment is patterned after similar equipment which is giving satisfactory service with a minimum amount of maintenance work. Rocky Flats and Los Alamos use equipment similar to this and have reported satisfactory operation with a minimum of maintenance work required.
3. Corrosion failures to equipment should be reduced. These reductions can be achieved as follows:
 - a. A more positive furnace seal will be obtained by maintaining a constant force on the sealing surfaces. In addition this seal will be cooled during the heating cycle and should last indefinitely. Furnace gaskets are replaced after every two or three runs in the present system.
 - b. HF gas is introduced directly into the filter boat; therefore, exposing only a small area of the retort to its corrosive action. In the present system the entire retort is exposed to HF gas.
4. The replacement of furnaces or furnace retorts would be cheaper both in material and labor costs when compared with the present system. The present furnace retorts cost \$1200 each and take approximately 40 man hours to replace. It is estimated that one of the new vertical furnaces would cost \$200 and could be replaced with a new furnace in less than 8 man hours.
5. By increasing the batch sizes in Task II by 67% it would be possible to decrease the maintenance costs because less equipment will be required to maintain the same level of production.

B. Reliability of Equipment

The continuity of operation of the present Task II system is dependent upon the lathe conveyor operating 100% of the time. At present if the lathe conveyor breaks down Task II is shut down until it has been

repaired because it is impossible to transfer filter boats by any other method. During repairs to off-gas lines, retorts, and other equipment inside of H-9, the operating efficiency of the conveyor is reduced. This reduction is due primarily to the safety hazards associated with operating the conveyor while maintenance work is being performed inside the hood.

In the new Task II system continuity of operation will not depend on the slat conveyor because in an emergency the filter boats could always be moved by hand from station to station. Each HF furnace is independently operated; therefore, while repairs are being made to a furnace it is unnecessary to shut down the Task because of safety hazards.

C. Capacity

The present capacity of Task II is 427 Kg/month using a time cycle of 4 hours and 10 minutes/batch. This time cycle is obtained by adding 18 minutes required for conveying to the time cycle shown in Figure 1. The capacity is based on 7 furnaces operating 24 hours/day and 22 days/month at 80% operating efficiency. At present the capacity of Task II is limited by the capacity of the filter boat when in the filter boat station. The capacity of the filter boat ranges from 600 units up to 850 units depending on the bulk density of the plutonium oxalate.

The capacity of a new Task II system could be increased to 575 Kg/month using a time cycle of 3 hours and 5 minutes/batch. This time cycle is obtained by adding 8 minutes for conveying to the time cycle shown in Figure 1. This capacity is based on 7 furnaces operating 24 hours/day and 22 days/month at 80% operating efficiency using 600 unit batches. This is an increase in capacity of 35% over the present system. This increase is due to the shorter time cycle brought about by faster cooling after the heating cycle is completed. Tests conducted on a vertical furnace in the 272-W shop indicated it took less than 20 minutes to cool the furnace from 480° to 200°C. In the present system the furnace is turned off and allowed to cool until an inside furnace temperature of 425°C. has been reached at which time the furnace is air cooled down to 200°C. before the boat can be removed. The present furnace is cooled slowly from 480°C. to 425°C. to prevent cracking of the welds in the retort. It is believed that slow cooling would not be required in the new Task II system because of lower retort temperatures brought about by better heat transfer between the retort and the boat and the use of fillets inside the retort which would reduce the high stress concentrations, a weakness in the present retort design.

A further increase in capacity can be obtained by operating the Task I reactors with batch sizes of 1,000 units instead of 600 units. The following increases would result when operating Tasks I and II 24 hours/day, 22 days/month at 80% operating efficiency.

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- a. Task I production could be increased from 311 Kg/month to 517 Kg/month when using the time cycle shown in Figure 2. This is a 67% increase in capacity.
- b. Task II production could be increased from 427 Kg/month to 962 Kg/month or a capacity increase of 125% over the present system.

4. Estimated Cost of Replacing Task II

An estimated cost of \$325,000 is required for replacing the present system with a new system using round filter boats and vertical HF furnaces. A detail breakdown of costs is shown on pages 11 and 12. This estimate was based on removing and burying the present Task II system which included H-9, the tie-in station between Task II and Task I and III, the seven HF furnaces, balance hood, and associated piping. It also included fabrication and installation of a new Task II system, modifications to the Task I filter boat stations, relocation of the balance and H-9WD, replacement of control desks in Zone 1 and a total of 18 new filter boats.

JR Fritz
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ENGINEERING DEPARTMENT

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REFERENCES

1. HW-29200 - "Plutonium Purification and Fabrication Technical Manual".
2. HW-29784 - "Scope and Proposed Sequence of 234-5 Building Design Development", by W. A. Brown.

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FIGURE 1 TASK I TIME CYCLE 234-5 BUILDING

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PROJECT NO. RDS-12		TITLE Minor Construction -- TASK II RMA LINE REPLACEMENT				HW-37152 Page 12		DATE PREPARED 10/4/54				
WORK PERFORMED BY: Minor Construction		WORK PERFORMED BY:				JOB TOTALS						
	LABOR	MATERIAL	EQUIP.	TOTAL	LABOR	MATERIAL	EQUIP.	TOTAL	LABOR	MATERIAL	EQUIP.	TOTAL
3	TOTAL DIRECT CONSTRUCTION COSTS											
	67,600	146,600	16,000	230,200								230,200
4	(A) CFFF SUB-CONTRACTOR INDIRECT COSTS (19 % OF LABOR - ITEM 3)											
				12,800								12,800
	(B) G. E. CONSTRUCTION DEPT. INDIRECT COSTS (19 % OF LABOR - ITEM 3)											
	(C) G. E. FORCES INDIRECT COSTS (19 % OF LABOR - ITEM 3)											
5	(A) FEE FOR CFFF SUB-CONTRACTOR											
	(B) FEE FOR LABOR SERVICE GROUP (4 % OF LABOR - ITEM 3)											
				2,700								2,700
6	CONSTRUCTION FIELD SUPV. AND INSPECTION (4 % OF ITEM 3) Fixed Amount											
				10,000								10,000
7	SUB - TOTALS											
				255,700								255,700
8	GENERAL OVERHEAD (2 1/2 % OF ITEM 7)											
				6,400								6,400
9	OPERATION AND MAINT. OF HQ, RICHLAND CAMP (1 1/2 % OF ITEM 7)											
				1,300								1,300
10	START UP COSTS											
11	ENG Services & SWP Clothing											
				10,000								10,000
12	CONSTRUCTION CONTINGENCY (10 % OF ITEM 7)											
				24,000								24,000
13	TOTAL CONSTRUCTION COST											
				297,400								297,400
14	ADJUSTED TOTAL CONSTRUCTION COST											
				295,000								295,000
15	ADJUSTED TOTAL DESIGN - ENG. COST (FORM F-1999 -S)											
				30,000								30,000
16	ADJUSTED TOTAL PROJECT COST											
				325,000								325,000
APPROVED (ENGINEERING)		DATE		APPROVED (ESTIMATING)		DATE		APPROVED (ACCOUNTING)		DATE		
				WJ Barton		10/5/54						

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