MAY 03 1999
Sta 15

ENGINEERING DATA TRANSMITTAL

Page 1 of 1
1. EDT 626775

2. To: (Receiving Organization) Distribution	3. From: (Originating Organization) Plutonium Finishing Plant	4. Related EDT No.: 626775 thru 626783
5. Proj./Prog./Dept./Div.: PFP Prog. Mgmt.	6. Design Authority/Design Agent/Cog. Engr.: J. C. Sinclair III	7. Purchase Order No.: N/A
8. Originator Remarks: For approval and release.		9. Equip./Component No.: N/A
		10. System/Bldg./Facility: N/A
		12. Major Assem. Dwg. No.: N/A
11. Receiver Remarks:	11A. Design Baseline Document? ☐ Yes ☒ No	13. Permit/Permit Application No.: N/A
		14. Required Response Date: N/A

15. DATA TRANSMITTED					(F)	(G)	(H)	(I)
(A) Item No.	(B) Document/Drawing No.	(C) Sheet No.	(D) Rev. No.	(E) Title or Description of Data Transmitted	Approval Designator	Reason for Transmittal	Originator Disposition	Receiver Disposition
1	HNF-4085		0	PFP Process Throughput	n/a	2	1	
				Calculation and				
				Basis of Estimate				

16. KEY					
Approval Designator (F)		Reason for Transmittal (G)		Disposition (H) & (I)	
E, S, Q, D OR N/A (See WHC-OM-3-5, Sec. 12.7)		1. Approval 2. Release 3. Information	4. Review 5. Post-Review 6. Dist. (Receipt Acknow. Required)	1. Approved 2. Approved w/comment 3. Disapproved w/comment	4. Reviewed no/comment 5. Reviewed w/comment 6. Receipt acknowledged

17. SIGNATURE/DISTRIBUTION (See Approval Designator for required signatures)										
(G) Reason	(H) Disp.	(J) Name	(K) Signature	(L) Date	(M) MSIN	(G) Reason	(H) Disp.	(J) Name	(K) Signature	(L) Date (M) MSIN
		Design Authority				3		R. M. Millikin		L5-65
		Design Agent								
1	1	Cog. Eng. J.C. Sinclair III								
2	1	Cog. Mgr. J.C. Sinclair, III			T5-50					
		QA				3		Central Files		B1-07
		Safety				3		DOE/RL Reading Room		H2-53
		Env.								

18. R.M. Millikin Signature of EDT Originator	19. J.S. Sinclair Authorized Representative for Receiving Organization	20. J.S. Sinclair Design Authority/Cognizant Manager	21. DOE APPROVAL (if required) Ctrl No. _____ ☐ Approved ☐ Approved w/comments ☐ Disapproved w/comments
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PFP Total Process Throughput Calculation and Basis of Estimate

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B&W Hanford Company

Richland, WA 99352

U.S. Department of Energy Contract DE-AC06-96RL13200

EDT/ECN: 626775

UC: 2000

Org Code: 15000

Charge Code: 103403/ar00

HN990431

B&R Code: EW04J1050

Total Pages: 7 9

Key Words: PFP, Process Throughput, Basis of Estimate

Abstract: This document includes the calculations and basis of estimate for the PFP process throughput used for the FY99 re-baseline of the PFP life-cycle baseline. Life-Cycle baseline is found in "Integrated Project Management Plan for the Plutonium Finishing Plant Stabilization and Deactivation Project, HNF-3617.

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Janis Aardal
Release Approval

5-3-99
Date

Release Stamp

Approved For Public Release

PFP Process Throughput Calculation and Basis of Estimate

HNF-4085, Rev. 0

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Prepared for

U.S. Department of Energy,
Richland Operations Office

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1.0 Introduction

The PFP Process Throughput Calculation and Basis of Estimate document provides the calculated value and basis of estimate for process throughput associated with material stabilization operations conducted in 234-5Z Building. The process throughput data provided reflects the best estimates of material processing rates consistent with experience at the Plutonium Finishing Plant (PFP) and other U.S. Department of Energy (DOE) sites. The rates shown reflect demonstrated capacity during “full” operation. They do not reflect impacts of building down time. Therefore, these throughput rates need to have a Total Operating Efficiency (TOE) factor applied.

2.0 Statement of Need

The PFP re-baseline effort utilizes an Activity-Based Cost (ABC) Estimate approach. During the analysis, each activity is estimated based on scope definition, interfaces, requirements, hazards, inputs/outputs, resource requirements and process evolutions or schedule duration. The total duration for material stabilization requires the evaluation and development of process throughput for quantity sensitive activities (i.e., Material Transfers, Thermal Stabilization Muffle Furnaces, $\text{Mg}(\text{OH})_2$, etc.).

3.0 Background

B&W Hanford Company assembled a team of planning and scheduling experts and personnel knowledgeable of PFP to develop an integrated baseline schedule for PFP. The process included development of process flow sheets for each process that identified each step required to perform the specific task. Once the flow sheets were complete, workshops were held to involve key facility personnel in development of cycle times and manpower requirements for each step in the process. This input was compiled to provide overall process cycle times, throughput capability, and manpower requirements. This document summarizes the cycle times and throughput capabilities for each process planned for PFP stabilization efforts.

4.0 Process Throughput Factors

The following discussions provide a narrative description of the process throughput factors for each of the analyzed processes. Process capacity is based upon equipment design. Cycle time is based upon the results of the workshop analysis of the process flow sheets. As a sanity check, the process throughput factors were compared to previous site experience or relevant experience at other DOE sites running similar processes.

4.1 $\text{Mg}(\text{OH})_2$ Precipitation

The throughput rate for $\text{Mg}(\text{OH})_2$ is based upon the throughput rates of Rocky Flats Plant (Denver, Colorado) on their Caustic Waste Treatment System process. Rocky Flats currently processes five liters an hour per precipitation tank, utilizing two precipitation tanks for a capacity

of 10 liters per hour. PFP will install three precipitation tanks with a total operating capacity of nine liters per hour. In an eight-hour day, it is expected that two precipitation cycles of three 12-liter precipitations can be made (2 cycles x 3 precipitators x 12 liters per precipitator / 8 hours per shift = 9 liters per hour). If a 12-hour split shift is used, three precipitation cycles can be achieved (3 cycles x 3 precipitators x 12 liters per precipitator / 12 hours per shift = 9 liters per hour). However, it is expected that processing rates will be limited by the ability to unload the bottles, blend, sample and analyze the blended solution to prepare it for feed. Current estimates (based on recent PFP experience) are that bottle unloading will be limited to two bottles per shift. This will yield a maximum unloading capability of 60 liters every 24 hours. For impure solutions, this will reduce the effective capacity to 7-8 liters per hour using a single eight-hour shift each day. If precipitation is used for the concentrated solutions, unloading capacity will not be limiting since the material will be diluted as much as 10 to one. However, there is only 120 liters of tank capacity to perform unloading and blending. This means that if blending is taking place at 10 to one, only one 10-liter bottle will be able to be unloaded and diluted at a time. This 100 liters of feed will have to be completely processed before the next bottle is unloaded and diluted. If a lower dilution factor is used, a blended feed volume of about 100 liters will still likely result. For diluted feed, a 12-hour split shift will yield a processing rate of 8-9 liters per hour based upon 100 liters of diluted feed per day.

Load in rate for 227-S Building:

2 PR cans per shift = 20 liters every 8 hours

3 shifts of load-ins = 60 liters every 24 hours

Blending, sampling, transfer of solution to adjoining batch tank and receiver tanks, and awaiting sample results = 8 hours (This can be performed on one tank while another tank is being filled.)

Feed Availability:

Impure solution – 60 liters / day

Pure solution – 100 liters / day

Processing Capability:

Impure feeds - five 12-liter precipitations per 8-hour shift limited by feed

Pure feed – eight or nine 12-liter precipitations per 12-hour split shift

4.2 Cementation

Throughput rates for cementation are based upon PFP experience. For sand, slag and crucible (SS&C), the cementation process is constrained by a feed mix input rate of 20 to 30 grams of SS&C per minute. The feed rate is limited to control the exothermic reaction between calcium metal and water. Upon completion of feed mixing, the slurry continues to be mixed until the temperature stabilizes. SS&C treatment and mixing typically take two to two and one-half hours. Once the material is stabilized, it is weighed to determine the amount of cement needed. The slurry mixture and cement are thoroughly mixed. This mixture is again weighed and then transferred to a billet container. The process of mixing with cement, weighing, filling the billet container, etc., is nominally one and one-half to two hours. The cycle time for 2 Kg of SS&C feed is four hours. A total of 12 Kg of SS&C can be cemented per day.

For other materials to be cemented, the process is the same except you reduce the mixing step from two and one-half hours to one and one-half hours since other feeds will not have an exothermic reaction with water. The feed quantity will still be about 2 kgs and will generally contain less than 100 g Pu. This yields a billet with less than 2 wt % Pu. With a three-hour cycle time, eight billets can be produced each 24-hour period if work is performed on a three-shift basis. A total of about 16 kgs of feed containing less than 800 g Pu can be cemented per day.

Cementation throughput rate for SS&C:

Reaction time per 2 Kg charge = 2.5 hours

Calculating and mixing with cement, weighing, filling billet container = 1.5 hours

Total:

Reaction time @ 2.5 hours + Cementing/disposition time @ 1.5 hours = 4 hrs for 2 Kg of SS&C

Cementation throughput rates for other residues:

Feed mixing time = 1.5 hours

Calculating and mixing with cement, weighing, filling billet container = 1.5 hours

Total:

Feed mix time @ 1.5 hours + Cementing/disposition time @ 1.5 hours = 3 hours for 2 Kg of residue feed

4.3 Muffle Furnace Operations

Throughput rates for muffle furnace operation are based upon current PFP experience. The cycle time for muffle furnaces includes the following: one hour for feed preparation, charging the furnace and updating glovebox inventories and data sheets, five hours to ramp the furnace to temperature, two hours dwell time at 1,000 °C, seven hours cool down time to 200 °C, one hour for additional cooling and to move the material out of the glovebox and bring in the new feed. These durations do not include material types that have additional dwell times such as sludge, or a longer dwell time at 1,000 °C such as ash. For example, the hot plate dried precipitate will be heated to a lower temperature and held for two hours to drive most of the remaining moisture before being calcined at 1,000 °C. Ash will have a longer cycle time due additional dwell time at 1,000 °C.

The furnace charge size is assumed to be the proposed 2.5 kg limit. The plutonium capacity for a furnace charge depends upon the oxide content of the material being processed. Precipitate from the solutions process will contain nominally 400-gm bulk charges per boat for all solutions.

With a standard cycle time for oxide of 16 hours, a total of seven cycles can be obtained each week of three-shift/five day operation. For other materials with 18-hour cycle times, a total of six cycles can be obtained each week of three-shift/five day operation. If a 20-hour cycle time is required, only five cycles can be completed in a week.

Throughput rate for thermal stabilization:

Charge makeup, transfer paperwork and charging furnace = 1 hour per charge

Ramp up, dwell, and cool down time = 14 hours per furnace charge

Cooling time after initial removal from furnace = 1 hour per charge

Total:

Material handling @ 1 hour + Furnace time @ 14 hours + Cooling time @ 1 hour = 16
hrs per furnace charge

Total available capacity using a standard furnace cycle:

2 furnaces @ 7 cycles / week = 14 cycles / week,

or;

5 furnaces @ 7 cycles / week = 35 cycles / week.

4.4 Pyrolysis

Throughput rates for the pyrolysis furnaces are based upon extensive Los Alamos National Laboratory experience obtained during their development and testing of this process. The cycle time for the pyrolysis furnaces includes: four-hour ramp up time for the furnace to get to operating temperature, two-hour dwell time at operating temperature, and six hours for cooling to 200 °C to allow for safe furnace insert handling. The charge size is 240 grams of polystyrene per furnace per batch. It is expected that two to three pyrolyzed polycubes will yield 240 grams of polystyrene. Limiting the charge size to 240 grams of polystyrene, keeps the off-gas treatment from limiting the cycle time. It takes approximately eight hours to treat the off-gas through the catalytic converters (240 grams polystyrene fed at 0.5 grams / in = 480 minutes = 8 hours). [Note: each furnace has its own off gas treatment system.] This time coincides with the combined furnace dwell and cool down time. Any further increase in charge size will extend the cycle time. The throughput rate for pyrolysis is one cycle of two furnaces each 12-hour split shift. Each furnace charge will contain two to three polycubes.

Throughput rate for Polycubes:

Ramp up, dwell, and cool down time = 12 hours per furnace cycle @ 240 grams
polystyrene charge (2-3 polycubes)

Total:

Capability is one cycle of 2 furnaces per 12 hour split shift = 4-6 cubes per day

Capability is nine cycles per week for 3 shift operation = 36-54 cubes per week

4.5 Pipe and Go

The pipe and go throughput is based upon Rocky Flats pipe and go experience and PFP repackaging experience. The pipe and go process is constrained by activities necessary to prepare the material for packaging in a pipe component. Three items can be weighed, inspected,

size reduced, blended, repackaged and sealed out every four hours. It was assumed that the glovebox criticality limits would accommodate sufficient quantities of plutonium to achieve repackaging rates up to six items in an eight-hour shift. Approximately 12 pipe components can be filled each eight-hour shift. The throughput rate for pipe and go is 12 containers every three shifts (two shifts for repackaging and one shift for putting into the pipe component).

Pipe and Go throughput rate:

Unpack, weigh, sieve, crush, resieve, sample, and containerize = 6 items / 8 hour shift
Pack material in to pipe components = 12 items / 8 hour shift

Total:

Pipe and go throughput rate = 12 items every 24 hours

4.6 Vertical Denitration Calcination

The throughput rate for Vertical Denitration Calcination (VDC) of two liters per hour was derived from research and development of the prototype calciner in Plutonium Process Support Laboratories. The feed input capacity will not limit processing two liters per hour. However, at feed rates higher than two and one-half liters per hour, VDC capacity will be limited by lack of feed. Processing the oxide solids from the VDC operations will not exceed the capacity of the thermal stabilization process to complete thermal stabilization. Throughput capability of the VDC will be 48 liters per day.

Load in rate for 227-S:

2 PR cans per shift = 20 liters every 8 hours
3 shifts of load-ins = 60 liters every 24 hours

VDC throughput rate:

2 liters per hour = 48 liters every 24 hours

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