SEP 11 1997 (21) Station 34

ENGINEERING DATA TRANSMITTAL

1. EDT 621299

2. To: (Receiving Organization) Plutonium Finishing Plant	3. From: (Originating Organization) Criticality and Shielding	4. Related EDT No.: N/A
5. Proj./Prog./Dept./Div.: PFP	6. Cog. Engr.: K. E. Hillesland	7. Purchase Order No.: N/A
8. Originator Remarks: Transmittal of CSER 97-004 evaluating the criticality safety of operating the PFP Denitration Calciner System in Glovebox HC-230C-2 in RM 230C.		9. Equip./Component No.: N/A
		10. System/Bldg./Facility: 234-5Z, PFP
11. Receiver Remarks: 11A. Design Baseline Document? [X] Yes [] No		12. Major Assm. Dwg. No.: N/A
		13. Permit/Permit Application No.: N/A
		14. Required Response Date: N/A

15. DATA TRANSMITTED

(A) Item No.	(B) Document/Drawing No.	(C) Sheet No.	(D) Rev. No.	(E) Title or Description of Data Transmitted	(F) Approval Designator	(G) Reason for Transmittal	(H) Originator Disposition	(I) Receiver Disposition
1	HNF-SD-SQA-CSA-529		0	CSER 97-004: PFP Production Denitration Calciner System	S	1,2		

16. KEY

Approval Designator (F)	Reason for Transmittal (G)	Disposition (H) & (I)
E, S, Q, D or N/A (see WHC-CM-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
1	1	Design Authority: GG Bergquist	[signature]	9/4/97	T5-55						
1	1	Design Agent: AL Ramble	[signature]	9/4/97	T5-54						
1	1	Cog.Eng.: KE Hillesland	[signature]	8/28/97	H0-35						
1		Cog. Mgr.: J Greenborg	[signature]	8/28/97	H0-35						
		QA N/A									
1	1	Safety: SE Nunn	[signature]	9/4/97	T5-11						
1	1	Tech Review. EM Miller	[signature]	8-27-97	H0-35						
1		Env.: N/A									

18.	19.	20.	21. DOE APPROVAL (if required)
K. E. Hillesland [signature] 8/28/97 Signature of EDT Originator / Date	G. G. Bergquist [signature] 9/4/97 Authorized Representative for Receiving Organization / Date	J. Greenborg [signature] 8/28/97 Design Authority/ Cognizant Manager / Date	Ctrl. No [] Approved [] Approved w/comments [] Disapproved w/comments

CSER 97-004: PFP Production Denitration Calciner System

Karl E. Hillesland
Fluor Daniel Northwest, Inc., Richland, WA 99352
U.S. Department of Energy Contract DE-AC06-96RL13200

EDT/ECN: ~~620290~~ 621299 KN
Org Code: 403
B&R Code: EW7040000

UC: 507
Charge Code: E56009
Total Pages: 100

Key Words: Criticality, Calciner, Plutonium

Abstract: The plutonium stabilization program at the Plutonium Finishing Plant (PFP) includes conversion of acidic plutonium nitrate solution into plutonium oxide. Conversion is facilitated through use of a vertical calciner installed in Glovebox HC-230C-2, which is located in RM 230C of this facility. This evaluation supports the Criticality Prevention Specification for the calcining process inside this glovebox. As the product of the calciner is a high density plutonium oxide, a number of limits are required to insure criticality safety. The containers allowed are product receiver vessels and 0.5 ℓ slip lid cans and polyjars. The limits allow for two "unit masses" of 2 ℓ total volume each, separated by a distance of at least 25.4 cm (10 in.). This evaluation allows for operation of the calciner for product densities not in excess of 5.5 g Pu/cm^3.

Karen G. Noland 9/11/97
Release Approval Date

SEP 11 1997
DATE:
STA: 34
HANFORD RELEASE
ID: 21
Release Stamp

Approved for Public Release

CONTENTS

CSER 97-004: PFP Production Denitration Calciner System

Prepared by: K E Hillesland Date: 8/28/97
K. E. Hillesland
Criticality and Shielding

Reviewed by: Edward M Miller Date: 8-28-97
E. M. Miller
Criticality and Shielding

Approved by: J. Greenborg Date: 8/29/97
J. Greenborg, Manager
Criticality and Shielding

1.0 INTRODUCTION AND SUMMARY

The plutonium stabilization program at the Plutonium Finishing Plant (PFP) includes conversion of acidic plutonium nitrate solution into plutonium oxide. Conversion is facilitated through use of a vertical calciner installed in Glovebox HC-230C-2, which is to be installed in RM 230C of this facility. This evaluation supports the Criticality Prevention Specification for the calcining process inside this glovebox.

Two unit masses of 2 ℓ volume each are allowed in the glovebox at a time with 25.4 cm (10 in.) spacing between unit masses. Allowable containers include 1 pound slip lid cans, polyjars, 30 mℓ sample jars, and product receiver vessels. Accumulations of fissile material on the glovebox floor shall not exceed a depth of 0.95 cm (3/8 in.). The basic safety controls are based on a maximum tap density of calcine product not in excess of 5.5 g Pu/cm^3. This report does not cover disassembly of the calciner.

2.0 LIMITS AND CONTROLS

1) The calciner may be operated without a mass limit if the tap density of the calcine product does not exceed 5.5 g Pu/cm^3. This density requirement may be met by frequent measurements of product tap density combined with immediate cessation of feed addition if a measurement indicates that the product tap density has exceeded 5.5 g Pu/cm^3.

2) The fissile concentration of feed solution shall be limited to no more than 450 g/ℓ of ^{239}Pu plus ^{235}U. ^{235}U content is included in this determination when uranium enrichment is above 1.0% ^{235}U. Uranium concentration is limited to a maximum of 50 g ^{235}U/ℓ of solution.

3) All plutonium in the glovebox shall have a minimum ^{240}Pu content of 5% by weight of plutonium, and a maximum ^{241}Pu content of 2% by weight of plutonium.

4) Accumulations of fissile material on the glovebox floor shall be limited to a depth of no more than 0.95 cm (3/8 in.). If accumulations of fissile material on the glovebox floor exceed 0.95 cm (3/8 in.) or there is a spill anywhere besides the floor of the glovebox, immediately discontinue adding feed to the calciner and/or glovebox until the limit for the depth on the glovebox floor has been reestablished and/or the spill has been cleaned up.

5) The lower insulation of the calciner shall be maintained free of absorbed fissile solution; if fissile solution is spilled on the insulation, feed to the calciner shall be discontinued and the insulation replaced before processing is resumed. A metal shell on the insulation is required to reduce exposure of the lower insulation to spills and leaks. Water absorbent insulation is not allowed on the upper portion of the calciner.

6) The depth of solids and precipitates with density greater than 450 g Pu/ℓ is limited to a total height of 25.4 cm (10 in.) in all tanks in the glovebox. Any solids accumulation in excess of 25.4 cm shall be investigated immediately for plutonium content. If the solids are found to exceed the concentration limit, they shall be removed from the tank in accordance with the approved written plan prior to continuing operations.

7) Containers allowed in the glovebox are 0.5 ℓ nominal volume containers, product receiver vessels, and 30 mℓ sample jars. Limits for containers are specified in terms of 2 ℓ unit masses. For the purpose of this limit, a product receiver shall be considered 1 ℓ.

   a) Container unit masses are to be spaced 25.4 cm (10 in.) apart edge to edge.

   b) There shall be a 25.4 cm (10 in.) spacing between any unit mass and the calciner vessel, excepting a single allowable unit mass beneath the bottom plate of the calciner.

   c) There shall be no more than two unit masses allowed in the glovebox at any time.

d) Stacking of containers is not allowed.

e) Containers may be placed on the glovebox floor, and not on any other horizontal surface.

f) 0.5 ℓ nominal volume containers shall have maximum dimensions no greater than 1 pound slip lid cans (part number 42-1500-300) and polyjars (part number 57-6359-160).

8) There shall be no more than ten clean-up rags (1 ft^2 area each) in the glovebox at a time. Only one is allowed adjacent to a given piece of equipment or a given container with fissile material at a time.

9) The valve on the product drop tube shall be opened only when a product receiver vessel is in place, or the calciner has been disassembled to insure no significant quantity of product remains in the calciner.

10) A sheared impeller shaft shall not be withdrawn from the assembled calciner.

11) The criticality drain in the glovebox shall be maintained in a freely-flowable condition.

12) The glovebox HC-230C-2 shall be seismically qualified.

13) Firefighting designation for the glovebox is Firefighting Category C.

14) Feed solution with plutonium concentration above 50 g/ℓ and a temperature below 65 degrees C shall have an acid concentration of at least 0.5 M.

3.0 PROCESS DESCRIPTION

Plutonium nitrate suitable for calcination in the vertical calciner is transferred from the HC-227S glovebox through double encased transfer line to a feed receipt tank located in HC-230C-2, RM 230C. A controlled volume is then gravity fed into the feed pump tank. Once the feed pump tank contains the appropriate amount of solution, the valve from the feed receipt tank is closed, and the solution in the feed pump tank is mixed with atomizing air flow into a preheated bed of PuO_2 powder in the vertical calciner. The vertical calciner agitates the injected mixture between external and internal heaters to 1000°C to form plutonium oxide (PuO_2).

Off-gases from this process are removed through the top of the calciner by vacuum. Sintered ceramic filter elements are used to remove any entrained plutonium dioxide powder. The off-gases are then circulated through a scrubber before leaving the glovebox. Spent scrubber solution is staged within the glovebox for sampling before removal from the glovebox.

4.0 ANALYSIS

The sources for all spatial dimensions were in English units. Therefore, the English units are given as they appear in the respective sources, and the equivalent metric units are given, rounded to four significant digits. The calculational input files also use English units for specification of spatial dimensions. All other dimensions are specified in SI units, and were entered as such in the calculational input files.

Appendix B provides a summary for the documentation (Maklin 1992, Miller 1994a) of the validation carried out for the MONK6B (UKAEA, 1992) Monte Carlo code and its predecessor versions as applicable to plutonium materials encountered at PFP. With the cross-section library supplied, the MONK6A/6B validation calculations indicate an allowed maximum k-effective (k_{eff}) value of 0.935 for new system calculations to assure subcriticality with an acceptable margin, including the uncertainties in the analytical methods and benchmark experimental data. The estimated standard deviation for all calculations in this analysis was less than 0.003.

4.1 CONCENTRATION AND COMPOSITION OF THE FISSILE MATERIAL

Mass fractions for many of the following were calculated on an Excel©[1] 5.0 workbook. The workbook is attached in Appendix C. ^{240}Pu is less reactive than ^{239}Pu, where as ^{241}Pu is more reactive. In this analysis, all plutonium is considered to contain 5% ^{240}Pu and 2% ^{241}Pu by weight of plutonium. Therefore, a minimum ^{240}Pu content of 5 wt%, and a maximum ^{241}Pu content of 2 wt% is specified as a limit on feed to the calciner.

4.1.1 Feed Solution

Feed solution at PFP may vary in plutonium concentration up to the allowable fissile concentration of 450 g Pu/ℓ in PFP and PUREX solution processes (Attachment 1). At 450 g Pu/ℓ, the density of plutonium nitrate solution is 1.75 g/cm^3, based on a theoretical density of 5.629 g/cm^3 for plutonium nitrate. This is the maximum plutonium concentration considered in this analysis.

4.1.2 Calcine (PuO_2) Product

The maximum expected tap density of the calcine product is 5.0 g Pu/cm^3, or 5.67 g/cm^3 for the oxide under normal operating conditions. This is based on experience with the PFP laboratory calciner, where normal product tap density was found to be 4.0 to 4.3 g Pu/cm^3. A

---

[1]Excel 5.0 is copyrighted by Microsoft Corporation. Microsoft is a registered trademark of Microsoft Corporation.

product density of 4.75 g Pu/cm^3 was reached when it was continuously heated and stirred without addition of fresh feed solution (Attachment 2).

Calcine product densities of 5.5, 6.0, and 6.5 g Pu/cm^3 were used for conservative evaluation of the calciner. However, operation of the calciner above 5.5 g Pu/cm^3 (6.24 g/cm^3 oxide) is not justified by this CSER.

4.1.3 Mud

Water flooding can be caused by earthquake and fire scenarios. Loss of feed solution containment may be caused by leaks in the feed solution system, including the possibility of a leak in the line bringing feed solution into the glovebox. In the event that the temperature interlock on the feed to the calciner fails, feed solution could be injected into a cold calciner. Each of these events allows for the formation of "mud" by mixing the liquid with the PuO_2 product. In this section, it will be shown that complete saturation of maximum density plutonium oxide with maximum concentration feed solution yields the most reactive mud composition.

The theoretical density of plutonium oxide is 11.46 g/cm^3 (Carter, 1968). Given an assumed product density, one may calculate the interstitial volume available for liquid saturation. For example, an assumed product density of 6.0 g Pu/cm^3 corresponds to a total PuO_2 product density of 6.80 g/cm^3. Comparison of this density to the theoretical density for PuO_2 indicates a void fraction of 0.406 in the product. Filling this void space with liquid would be considered full saturation.

The cases listed in Table 1 were modelled with the calciner full of mud, the calciner filters filled with 450 g Pu/ℓ feed solution, and the calciner lower insulation saturated with water. The floor is covered with 0.9525 cm (3/8 in.) of the same mud as in the calciner, and above it, 4.445 cm (1 3/4 in.) of 450 g Pu/ℓ feed solution which reaches to the top of the criticality drain. The scrubber tank and two feed tanks are filled with 140 g Pu/ℓ feed solution above the 25.4 cm (10 in.) particulates. Two product receiver vessels filled with the same mud as in the calciner are under the calciner and two 25.4 cm (10 in.) away towards the scrubber tank. The calciner mud was made of various density calcine, 450 g Pu/ℓ feed solution or water, and at different saturations to vary the H/Pu to find the most reactive mud. For the dry case, the calciner and product receiver containers hold dry product and the filters are full, but the tanks are as described for the other cases, and the mud on the floor is saturated with 450 g Pu/ℓ solution. As internal flooding of the calciner is considered an independent event from flooding external to the calciner, these cases represent two contingencies, resulting in k_{eff}s above the allowable in some cases. To form some of the higher H/Pu ratios, it is necessary to reduce the plutonium oxide density.

Most cases were run for plutonium solution (plutonium and water only), excluding the nitrate in feed solution. This is conservative in comparison to an equivalent case using plutonium nitrate, and allows for easier comparison to the cases involving water saturation. Case *sol55n* shows that the reactivity drops over 0.020 in k_{eff} when nitrate is included at a total plutonium density of 5.71 g Pu/cm^3.

Table 1 indicates that for product densities up to 6.0 g Pu/cm^3, the most reactive mud is formed from 6.0 g Pu/cm^3 PuO_2 fully saturated with 450 g Pu/ℓ solution, forming the material with the highest plutonium density.

Table 1. Reactivity for Various Forms of "Mud"

Case	Product Density (g Pu/cm^3)	Total Pu Density (g Pu/cm^3)	Liquid	Percent Saturation	H/Pu	k_{eff}	Std. Dev.
solsp50	5.00	5.23	Pu solution	100%	2.51	0.9438	0.0029
sol55n	5.50	5.71	Pu nitrate	100%	1.78	0.9443	0.0029
solsp55	5.50	5.71	Pu solution	100%	2.07	0.9650	0.0029
solsp	6.00	6.18	Pu solution	100%	1.71	0.9807	0.0029
HPu50s	6.00	6.09	Pu solution	44%	0.85	0.9354	0.0029
HPu25s	6.00	6.05	Pu solution	22%	0.43	0.9243	0.0029
HPu0	6.00	6.00	(none)	0%	0.00	0.8997	0.0029
HPu50w	6.00	6.00	Water	49%	0.88	0.9254	0.0029
HPu100w	6.00	6.00	Water	100%	1.80	0.9673	0.0029
HPu450w	4.00	4.00	Water	100%	4.01	0.9027	0.0029
HPu1200w	2.00	2.00	Water	100%	10.6	0.8486	0.0029

4.1.4 Precipitated Pu Solids in Tanks

Precipitation of plutonium solids from nitrate solution is modeled as plutonium nitrate at 2 g Pu/cm^3 mixed with water. This gives a total density of 4.35 g/cm^3 based on a theoretical density of 5.629 g/cm^3 for plutonium nitrate, filling the remaining interstitial volume with water. The 2 g Pu/cm^3 is considered a reasonable value. In general, the densest precipitate is plutonium oxide (Miller, 1997a). Plutonium oxide formed from plutonium nitrate at temperatures below 400° C has a bulk density of no more than 2 g PuO_2/cm^3 according to Page III.C.2-2 of ARH-600 (Carter, 1968).

At 450 g Pu/ℓ of solution in the feed tanks, the 10 ℓ nominal volume can hold 4.5 kg of plutonium. The plutonium mass for 2 g Pu/cm^3 at the allowable 25.4 cm (10 in.) layer of precipitate amounts to a total mass of 9.8 kg in each tank. Therefore, the density for the precipitate together with the allowable height is considered conservative.

4.1.5 Uranium Content

Some of the samples to be calcined contain ^{235}U. The Nuclear Criticality Safety Manual HNF-CM-4-29 Section 5.2.1.4 states that 1 g of ^{235}U may be considered equivalent to 1 g of ^{239}Pu. In Section 5.2.1.3 of the same chapter, solutions with enrichments of less than 1.0% are considered exempt from criticality safety control. Therefore, for solutions of enrichment above 1.0%, 1 g of ^{235}U will be considered 1 g of ^{239}Pu for purposes of concentration (450 g/ℓ), density and mass limits. As the equivalence is valid for "small quantities ... associated with plutonium processing", the equivalence will be considered valid for solutions with ^{235}U content of up to 50 g ^{235}U/ℓ. Attachment 3 indicates that no enriched uranium concentrations above this level are expected. For solutions of greater than 1.0% ^{235}U enrichment and greater than 50 g ^{235}U/ℓ, additional analysis will be necessary.

4.2 GLOVEBOX

Most of glovebox HC-230C-2 was originally constructed for the Fuels and Materials Examination Facility (FMEF). One portion of the glovebox (hereafter referred to as the "calciner section") is primarily used for the actual calcination process. Another section (hereafter referred to as the "waste section") is used to process waste scrubber solution. The third section (hereafter referred to as the "connecting section") connects the HC-230C-2 glovebox to the HC-3 conveyer for further processing.

4.2.1 Calciner Section of Glovebox

The derived inner dimensions of the calciner section are 105 cm (41 1/4 in.) x 264 cm (104 1/4 in.) in the two horizontal directions. These values are based on scaling from a preliminary drawing (Attachment 4, Drawing A) and hand measurement (Attachment 5). The height scaled from the preliminary drawing is 180 cm (70 7/8 in.). The basic model for the calciner section contains the following fissile quantities:

- The calciner is filled with 6.0 g Pu/cm^3 dry PuO_2 product up to the bottom of the dome, amounting to a total volume of approximately 1.6 ℓ. This section of the calciner is surrounded by 30.48 cm (12 in.) thick insulation saturated with water.

- Three product receiver vessels are beneath the calciner, and three more are beneath the feed pump tank, which amounts to two overbatches. Each container is filled with 6.0 g Pu/cm^3, dry product, and surrounded by a 2.54 cm thick annulus of water representing hands.

- There is a 0.9525 cm (3/8 in.) thick layer of 6.0 g Pu/cm^3, dry product covering the entire glovebox floor.

- Both feed tanks and the scrubber tank are completely filled with 140 g Pu/ℓ feed solution, excepting a 25.4 cm layer of 2 g Pu/cm^3 precipitate on the bottom of each. Section 4.4.3 shows that 140 g Pu/ℓ feed solution is more reactive than 450 g Pu/ℓ feed solution. Filling the 20 ℓ scrubber tank with feed solution, which normally would have none, conservatively compensates for pumps and piping not included in the models.

The walls of the glovebox (0.9525 cm or 3/8 in. thick) are made from lead (0.4763 cm or 3/16 in.) sealed between two layers of steel (Miller, 1997b). The model uses a 30.48 cm (1 ft.) layer of water on all four sides of this section to represent the bodies of workers. A 30.48 cm (1 ft.) layer of water is placed on the top and bottom of the glovebox as well to bound reflection from the floor and ceiling. Since steel is an absorber, and the 30.48 cm of water will provide full reflection, the steel and lead materials of the glovebox itself are excluded from the model. This model is also conservative in that it includes the water reflector at the side of the calciner section that would in actuality be shared with the connecting section. The keff $\pm$ 1σ for this system (case *undert3*) is 0.8929 $\pm$ 0.0029. This basic model is modified to construct each specific contingency case.

Because the calciner section contains the bulk of the fissile material and is modelled with 30.48 cm (1 ft.) thick water reflector on all four sides, top and bottom, analyses of the calciner section of the glovebox are considered bounding for analysis of the entire glovebox.

4.2.2 Waste Section of Glovebox

The waste section of the glovebox contains solution used for scrubbing of the off-gasses that come from the calciner. The width of the glovebox (minimum horizontal dimension) is indicated as 107 cm (42 in.) based on a preliminary drawing with dimensions (Attachment 4, Drawing B), and scaling from a second preliminary drawing (Attachment 4, Drawing A). Although it is suspected that the width should be equal to that of the calciner section, the value of 107 cm is considered adequately accurate for this analysis. The height was taken to be the same as the calciner portion (180 cm or 70 7/8 in.). The model for the waste section includes two tanks (four cylinders) for storage of spent scrubber solution. These tanks are referred to as spent scrubber receipt tanks (SSRTs).

The walls of the glovebox are made from lead sealed between two layers of steel. This is replaced by a 30.48 cm (1 ft) layer of water on all sides of the glovebox used to represent the bodies of workers as is done for the connecting section (Section 4.2.1). There is also a 30.48 cm (1 ft) layer of water on the top and bottom to bound reflection from the floor and ceiling. The water reflector is also present at the side of the calciner section that would in actuality be shared with the connecting section. The total length of the waste section is modelled as being only 124.5 cm (49 in.). This is conservative in that it brings the water reflector closer to the SSRTs. As the SSRTs are much larger in volume than the single vent catch tank, and filling the single vent catch tank is considered an independent contingency (see Sections 4.4.2 and 4.5.4), analysis for filled SSRTs is considered bounding for this analysis. Section 4.5.2 discusses the contingency of abnormally high fissile material content in the SSRTs.

4.2.3 Connecting Section of Glovebox

The connecting section of the glovebox will provide access to one end of the HC-3 conveyer glovebox. Operators will need to move 0.5 ℓ slip-lid cans 1.8 m (6 ft) by hand from the connecting section of the glovebox to the end of the conveyor to be transported to glovebox HC-21A for storage in the Hanford Convenience Can (HCC). The phase separation tank is on the border of this section and the calciner section. It is considered in the calculations of Section 4.5.3 as an extension to the model for the calciner section. The only other potential for the presence of fissile material is accumulation on the floor and the presence of unit masses. Therefore, no independent calculations were made for the connecting section. Analysis for the calciner section of the glovebox should be bounding for the connecting section.

4.2.4 Criticality Drain

There is a vertical, bottom criticality drain located in the floor of the calciner section of the glovebox to limit the level of liquid accumulation in the entire glovebox. The criticality drain was measured in the fabrication shop as having a height of approximately 3.65 cm (1 7/16") above the glovebox floor, not including the height of the gasket. This value is based on measurements of two parts of the criticality drain, a portion that was installed at the time, and a second portion that was measured outside of the box. Consequently, the total height used in this analysis will be 4.1275 cm (1 5/8") to account for any inaccuracies in measurement. The inside diameter of the drain was measured in the fabrication shop as being a little under 7.62 cm (3 in.).

Although there are a number of weirs on the floor of the glovebox, none are as tall as the top of the criticality drain. Therefore, the criticality drain will limit the level of liquid in all portions of the glovebox.

The "Criticality Drain Performance Study" (Lehmkuhl, 1974) shows that for a flow rate of 14 gallons per minute, there is a head of less than 1.27 cm (1/2 in.) for a 7.62 cm (3 in.) criticality drain. Since the highest flow rate into a glovebox reported in the "Z-Plant Sprinkler System Criticality Safety Analysis Report" (Hammelman, 1974) is 6.0 gallons per minute, the 1.27 cm (1/2 in.) head is considered bounding for this analysis. Therefore, the maximum height of liquid accumulation on the bottom of the glovebox is taken as 5.3975 cm (2 1/8 in.). For the calciner section of the glovebox, this would correspond to a total volume of 149 ℓ.

4.2.5 Accumulation of Fissile Material on Glovebox Floor

Accumulations of fissile material on the glovebox floor is administratively limited to a depth of no more than 0.95 cm (3/8 in.). Consequently, all calculations include a 0.9525 cm (3/8 in.) layer of PuO_2 on the glovebox floor unless specified otherwise. Table 2 shows the effect of doubling this thickness to 1.905 cm (3/4 in.) at a product density of 6.0 g Pu/cm^3. As can be seen, this contingency results in only a small change in reactivity. Case *undert3* is the base case for the calciner portion of the glovebox as described in Section 4.2.1. Case *buildup* is the same case, but with the double batch of material on the glovebox floor. A doubling of accumulation on the floor results in a small change in k_{eff} because the reactivity of the glovebox is primarily due to the product receiver vessels in this model. This is demonstrated by case *bf*. Case *bf* differs from case *buildup*, only in that the calciner has been completely filled with product, and the off-gas filters in the calciner filled with feed solution. The calculated k_{eff} for case *bf* is actually lower than case *buildup*, but within two sigma.

Table 2. Buildup of Material on Glovebox Floor

Case	Product on Floor	Product in Cacliner	k_{eff}	Std. Dev.
undert3	0.9525 (3/8 in.)	1.6 L	0.8929	0.0029
buildup	1.905 (3/4 in.)	1.6 L	0.9081	0.0029
bf	1.905 (3/4 in.)	full	0.9039	0.0029

4.2.6 Water Flooding of the Glovebox

Water flooding can be caused by earthquake and fire scenarios. This contingency considers a worst case flood of the glovebox. This model represents a modification of the model for the calciner portion of the glovebox as described in Section 4.2.1. In the model for this contingency, the allowable 0.9525 cm (3/8 in.) layer of product on the glovebox floor is saturated with 450 g Pu/ℓ feed solution without the nitrate. Solution saturation represents an additional conservatism over water saturation.

All containers on the floor are assumed to be full of PuO_2 product saturated with 450 g Pu/ℓ feed solution without nitrate as well. The containers consist of two product receivers beneath the feed pump tank and two beneath the calciner. There are no water hands around these containers, as there should be no one operating the calciner during flooding conditions. The internal space of the calciner section is filled with "mist" and the insulation left dry. The effect of wet insulation is discussed in Section 4.3.4 and shown in Table 7. The calciner is completely filled with dry product. All product has a plutonium density of 5.5 g Pu/cm^3. Results for the various mist conditions are shown in Table 3.

The k_{eff} is below the 0.935 allowable for mist densities up to 0.2 g/cm^3. Even at 0.5 g/cm^3, the k_{eff} is 0.9379, which is only slightly over the allowable of 0.935. In either case, the density is far greater than any expected mist density due to sprinklers or other fire fighting activities. The system is considered sufficiently subcritical under this contingency.

Table 3. Calculations for Water Flooding of the Glovebox

Case	Mist Material	Mist Density (g/cm^3)	k_{eff}	Std. Dev.
nomist	(none)	(none)	0.7378	0.0029
wmp001	water	0.001	0.7358	0.0029
wmp002	water	0.002	0.7350	0.0029
wmp005	water	0.005	0.7439	0.0029
wmp01	water	0.01	0.7385	0.0029
wmp02	water	0.02	0.7404	0.0028
wmp05	water	0.05	0.7730	0.0029
wmp1	water	0.1	0.8112	0.0029
wmp2	water	0.2	0.8522	0.0029
wmp5	water	0.5	0.9379	0.0029
wm1	water	1.0	0.9912	0.0029

4.2.7 Feed Solution Flooding of the Glovebox

Loss of feed solution containment may be caused by leaks in the feed solution system, including the possibility of a leak in the line bringing feed solution into the glovebox. This model represents a modification of the model used in the previous section for a water flood contingency (Section 4.2.6). In addition to the allowable 0.9525 cm (3/8 in.) layer of product on the glovebox floor saturated with feed solution, there is also a layer of feed solution up to the maximum liquid level allowed by the criticality drain (5.3975 cm or 2 1/8 in.). Therefore, the buildup of material on the glovebox floor for flooding is as follows:

Top
4.4450 cm (1 3/4 in.) feed solution
0.9525 cm (3/8 in.) feed solution mud
Bottom

The layer of solution on the floor amounts to a total volume of 123 ℓ in the calciner section as modeled. This volume does not include that of the other two sections of the glovebox. As the total volume of the two feed tanks is nominally 20 ℓ and the total volume of solution in the feed line coming into the box under extreme circumstances is 54 ℓ (Attachment 6), the assumed layer of feed solution represents an incredible amount of solution for a feed spill.

Again, nitrate is neglected, adding an additional level of conservatism. The containers consist of two product receivers beneath the feed pump tank and two beneath the calciner. All containers are assumed to be full of PuO_2 product saturated with feed solution. The feed solution on the floor and saturating the product to form mud is modeled as 450 g Pu/ℓ plutonium solution, thus conservatively neglecting the nitrate. All product has a plutonium density of 5.5 g Pu/cm^3.

Because the calciner is hot, there is some chance that feed solution could be flashed to steam, driving droplets of feed solution into the air. Some droplets may arise from a feed leak, even for a low pressure pump. Three cases were run in which there is a mist of feed solution (modeled as plutonium solution, neglecting nitrate) at densities of 0.001 g/cm^3 to 0.1 g/cm^3. However, a mist density of 0.001 g/cm^3 is two orders of magnitude greater than flog, clouds, or rain. Even at this density, the k_{eff} for the glovebox is below 0.9. Raising the mist density to the extremely conservative density of 0.01 g/cm^3, the k_{eff} is still less than the allowable of 0.935. This shows that as a mist of feed solution increases, k_{eff} increases slowly at possible mist densities. The highest mist concentration considered is 0.1 g/cm^3, for which the k_{eff} is over 1.00. However, this represents an incredible amount of feed solution (~ 500 kg) in the glovebox.

Table 4. Calculations for Feed Solution Flooding of the Glovebox

Case	Mist Density (g/cm^3)	k_{eff}	Std. Dev.
smp001	0.001	0.8928	0.0029
smp01	0.01	0.9119	0.0029
smp1	0.1	1.0484	0.0029

4.3 VERTICAL CALCINER

The production vertical calciner is virtually identical to the prototype currently in the 188-1 glovebox at PFP. Drawing number H-2-95609 (BWHC, 1997) shows dimensions for this new production calciner. The outer vessel of the calciner consists of two sections of 310 stainless steel, 6 inch schedule 10 pipe. The dimensions for this pipe as modeled are 16.15 cm (6.357 in.) ID, 16.83 cm (6.625 in.) OD. Details specific to each section of pipe are given below.

4.3.1 The Lower Section

The heating and agitation of the product take place in the lower portion of the calciner. There is a dome made from 4 inch pipe and pipe cap in the center, which is modelled as extending up 17.95 cm (7.066 in.) into the internal volume of the calciner from the bottom. No credit is taken for the volume occupied by the agitator, except that the rod is modeled as having its lower end 2.54 cm (1 in.) above the top of the dome. Although the product collection tube will often be filled with product during normal operating conditions, it is considered of negligible importance for criticality safety due to its small radius (2.54 cm) and because it only extends up into the annular region of the calciner where reactivity is lowest. The product collection tube is not included in the model, except as discussed in Section 4.3.3.

This section is wrapped in a highly water absorbent insulation with approximate dimensions as given in Attachment 7. Although the thickest portion of the insulation is 15.24 cm (6 in.), the insulation is modelled as a close-fitting annulus just over 30.48 cm (12 in.) thick along its entire axial length. This is conservative because the insulation is 10.16 cm (4 in.) thick and its inner surface is 9.366 cm (3.688 in.) from the outside surface of the calciner vessel along most of the middle portion of the insulation's axial length.

Visible inspection for dryness is not possible because the insulation is covered by a metal cover to prevent liquid contacting the insulation. All calculations will consider water saturation of the insulation as part of the normal condition as a conservatism (see Section 4.3.4.1 below) to represent spills of non-fissile solutions and condensation buildup when the calciner is cooled down. As feed solution is contained within a closed system in the glovebox, a feed solution spill is considered a contingency. If fissile material is spilled on the insulation, feed to the calciner shall be discontinued and the insulation replaced before processing is resumed. This contingency is addressed in Section 4.3.4.2.

4.3.2 The Upper Section

The upper calcining section contains filter elements for filtering particulates from the off-gasses produced in the calcining process. The filters were modeled based on dimensions from the model used in CSER 95-005 for the calciner in glovebox 188-1 (Geiger, 1995a and 1995b) and a third party reference to personal correspondence with L.H. Rodgers, as there were no drawings made available for these dimensions. These dimensions were used in the base case model for the calciner section of the glovebox as described in Section 4.2.1. Later hand measurements of the production calciner filters by J.F. Durnil yielded different internal dimensions (Attachment 8). A list of dimensions for both filter models is given in Table 5 below. Using the shorter length is conservative since a shorter filter leaves more room for product in the calciner. The inside dimensions are important only for the case of feed solution filling the calciner as discussed in Section 4.3.5.

Table 5. Off-Gas Filter Dimensions

Dimension	From CSER 95-005 (Geiger, 1995a)	Measurement by J.F. Durnil (Attachment 8)
Total Length	30.48 cm (12 in.)	30.80 cm (12 1/8 in.) - modeled as 30.48 cm (12 in.)
Outside Diameter	5.080 cm (2 in.)	5.080 cm (2 in.)
Inside Diameter	2.870 cm (1.13 in.)	3.651 cm (1 7/16 in.)
Bottom Thickness	3.810 cm (1.5 in.)	2.858 cm (1 1/8 in.)

This section is wrapped in metal reflective insulation that does not absorb liquids (see Appendix B of Geiger, 1995b). The manufacturer supplied drawings show an outside diameter of 40 cm (15.75 in.) and a height of 36.83 cm (14.5 in) for the prototype calciner. These are the dimensions used for the production calciner, as there was no information available on these dimensions at the time of the analysis. The insulation was conservatively modeled as being 10% density 304L steel to accommodate the concentric sheets and narrow strips of sheet metal used to create many spaces of dead air within the insulation. Later correspondence revealed that the insulation on the upper insulation contains less mass than modeled. In any case, the amount of steel modeled is quite small, and would have little effect on reactivity.

4.3.3 Product Collection Tube

A product collection tube is used to feed the final product from the calciner into product receiver vessels. The outside pipe of the tube is 1 in. sched 10s pipe. The top of the tube is inside the center dome of the calciner. There is a 11.43 cm (4.5 in.) tall slot in the side of the dome, and a slot cut into the side of the tube to allow product to flow from the calciner down the tube into an attached product receiver vessel. The height of the product inside the calciner is controlled by a weir inside the tube. The flow of product is controlled by a valve attached to the product collection tube. The tube was found to adjust such that the bottom may range between 12.7 cm (5 in.) to 30.48 cm (12 in.) from the glovebox floor based on hand measurement in the fabrication shop (Attachment 5).

If the valve is left open while there is no product receiver in place, material from the calciner may spill on the glovebox floor. Cases *hand* and *undert3*, in Tables 15 and 9 respectively, include an overbatch of containers beneath the calciner amounting to nearly 3 ℓ, each container being surrounded by a one inch water annulus. This should constitute a bounding evaluation for a spill of material on the floor due to opening the valve on the product collection tube when no product receiver vessel is in place. Neither case exceeds a k_{eff} of 0.91.

4.3.4 Wet Insulation

In this scenario, the insulation on the bottom portion of the calciner is saturated with water. As given in Appendix E of CSER 95-005 (Geiger, 1995a) the insulation has 90% void space by volume.

Appendix B of the addendum to CSER 95-005 (Geiger, 1995b) contains a test that shows that the "mirror" insulation used in the upper section of the calciner drains at a rate of 25 ℓ/minute, indicating that a fill rate of at least 25 ℓ/minute would be required to cause accumulation of liquid in the insulation. Consequently, to fill the insulation on the upper section with water is considered incredible. However, additional water at 0.1 g/cm^3 is added to this volume to bound the amount of water that may cling to the inner and outer surfaces of this insulation when soaked insulation is considered.

4.3.4.1 Water Soaked Insulation

Two cases were run to show the effect of water completely saturating the lower insulation under otherwise normal operating conditions. This model represents a modification of the model for the calciner portion of the glovebox as described in Section 4.2.1. In each case, the product is dry and has a plutonium density of 6.5 g Pu/cm^3. The second unit mass is 25.4 cm (10 in.) from the first unit mass in the direction of the scrubber tank in Section 4.6.4. The model does not include water annuli to represent hands. The results given in Table 6 indicate little effect on reactivity due to water saturating the insulation. This rather unexpected result is attributed to the fact that the fissile material in the calciner is only within a thin annulus. The reactivity level is primarily due to the interaction of the more solid volumes of plutonium in the tanks and containers.

Table 6. Water Saturating Insulation

Case	Lower Insulation Status	k_{eff}	Std. Dev.
down	dry	0.7606	0.0029
wet	wet	0.7686	0.0029

An additional case was run to show the effect of saturating the insulation of the calciner with feed solution under flooding conditions as described in Section 4.2.6. Table 7 shows a comparison between the worst case credible flooding condition with dry and wet insulation (0.2 g/cm^3). As the results are within one sigma of each other, this indicates that adding wet insulation does not change reactivity appreciably when mist is already present.

Table 7. Water Saturation of Insulation Under Flood Conditions

Case	Insulation Status	k_{eff}	Std. Dev.
wmp2	dry	0.8522	0.0029
wetp2	wet	0.8501	0.0029

4.3.4.2 Feed Solution Soaked Insulation

The lower insulation on the calciner has a 90 percent void space and absorbs water rapidly (see Appendix E of Geiger, 1995a). The dimensions of the insulation make it an unfavorable "container" if saturated with feed solution.

Feed solution is contained within a closed system in the glovebox. Feed solution can only saturate the lower calciner insulation if a pressurized feed line has a guillotine break. The break would have to go unnoticed for a sufficient amount of time to allow for significant buildup of solution in the insulation. Secondly, a required metal casing around the lower insulation will deflect a stream of feed solution from a pipe break from reaching the insulation.

The feed line entering the glovebox to the first (feed receipt) tank is pressurized. In addition to the conditions mentioned above, there would have to be a stream of solution directed at the calciner for a break in this line to cause saturation of the insulation. The pressure would also need to be sufficient to reach the insulation. That the insulation would actually become completely saturated with feed solution is considered incredible from a break of this nature.

The only other feed line under pressure is between the feed pump and the calciner. This line enters the calciner from below after passing through the hole in the center of a metal plate approximately 71 cm (28 inches) in diameter. This plate provides a second barrier for breaks in the feed line beneath it.

The pump used for feeding solution into the calciner is an LMI Metering Pump Model E70, with a maximum output of 4.9 ℓph (LMI, 1996). To saturate the lower insulation of the calciner with 3 ℓ of solution would require that a leak go unnoticed by the operator for 37 minutes, assuming that all the feed solution being pumped at the maximum pump capacity is absorbed by the insulation. The loss of head because of the elevation change from the pump to the insulation and the loss of solution to other flow paths would reduce that absorbed by the insulation below this amount. Furthermore, solution buildup in the insulation at the bottom of the calciner is not as much a problem from a criticality standpoint as solution buildup near the top of the lower insulation, where there is a larger cross-section of product. This larger cross-section of product would only be the result of an abnormal accumulation above the outlet tube.

It is considered incredible that the insulation would be completely saturated with feed solution. An evaluation is made for saturation of the insulation with a smaller, more credible amount of feed solution. Cases involving 3 ℓ solution spills from Addendum 1 of CSER 95-005 (Geiger, 1995b) are considered bounding for any credible feed solution leak. In the analysis of this addendum, there were four configurations considered. Descriptions and calculated k_{eff}s for these configurations are given below. The values given are for 6.5 g Pu/cm^3 in the PuO_2 product.

1) The $k_{eff} \pm 1\ \sigma$ for plutonium nitrate solution saturating an annular shell against the inner surface of the insulation, with water saturating the remainder of the insulation was calculated to be 0.8562 ± 0.0040.

2) The $k_{eff} \pm 1\ \sigma$ for plutonium nitrate solution saturating a slab against the top surface of the insulation, with water saturating the remainder of the insulation was calculated to be 0.8496 ± 0.0040.

3) The $k_{eff} \pm 1\ \sigma$ for plutonium nitrate solution saturating the outer "half" of a torus (vertical cross section a semicircle) with the inner cylindrical surface coinciding with the inner surface of the insulation at the top, and with water saturating the remaining insulation was calculated to be 0.8595 ± 0.0043.

4) The $k_{eff} \pm 1\ \sigma$ for a homogeneous mixture of water and the spilled plutonium nitrate solution saturating the entire volume of the insulation was calculated to be 0.9328 ± 0.0042.

In all four of these configurations the calculated keff was below 0.935. For a Pu density in the calcine of 7.0 g/cm^3, an incredible density for the calciner and a violation of the density limit, case 4 exceeds the allowable.

4.3.5 Internal Flooding

The calcine inside the calciner may be turned into "mud" as described in Section 4.1.3 in the event that the temperature interlock on the vertical calciner fails, allowing the feed pump to continue to provide fresh solution into the cold calciner. This contingency is considered in Table 8. The interior of the calciner is completely filled with the most reactive plutonium solution mud found in Section 4.1.3 surrounded by wet insulation. The model also assumes that the internal volume of all three filter elements are filled with 450 g Pu/cm^3 solution. This model represents a modification of the model for the calciner portion of the glovebox as described in Section 4.2.1.

The calciner model for calculations in this section does not include the 1.27 cm (1/2 in.) steel plate at the bottom of the dome of the calciner, thus maximizing interaction between the product in the calciner and the product receiver vessels on the floor by neglecting the shielding mass of the heating element and the feed injection system that is between the calciner and the product receiver vessels. These cases also include revised internal dimensions for the off-gas filters as discussed in Section 4.3.2. By expanding the internal dimensions of the filters, the volume of feed solution inside the filters is increased.

Two product receivers are located under the calciner, and two under the feed pump tank, all with water hands surrounding them. All containers are filled with dry calcine, with the exception of one product receiver vessel considered to have been attached to the bottom of the calciner at the time of the failure. This product receiver vessel is filled with the same mud as in the calciner, which has an H/Pu ratio above 2.073. The operator will notice abnormal wetness at this level, and should stop work until a written recovery plan is in place.

Case *int55dv5* includes both containers on the floor of the glovebox, with the mud filled container attached to the product drop tube. In case *int55uv5*, the containers are up against the bottom of the calciner baseplate, even though the presence of hardware such as the feed solution injection system would disallow this. Also, it is not expected that the operator would detach the identifiably mud filled jar and move it together with the jar of dry calcine up above the bottom of the product collection tube as is modeled in case *int55uv5*. The k_{eff}s for both cases are below the allowable.

Table 8. Internal Flooding for Cases Including the Product Collection Tube

Case	Mud Filled Container Position	Dry Product Filled Container	k_{eff}	Std. Dev.
int55dv5	floor	floor	0.9298	0.0029
int55uv5	up	up	0.9296	0.0029

4.4 FEED SYSTEM

The feed system for the calciner is mainly located within the calciner portion of the glovebox. The calciner portion of the glovebox includes two feed tanks, a flush tank, feed lines, valves, air supply, and a pump for the feed system. The vent catch tank in the waste section of the glovebox is used to catch overflow from the feed tanks and the flush tank.

4.4.1 Feed Tanks

Both feed tanks are made from 6 inch Pyrex®[2] pipe. Vendor data (Wittekind, 1997) indicates an inside diameter of 15.71 cm (6.186 in.) including tolerances. The height of both tanks is nominally 60.96 cm (24 in.), yielding a total volume capacity of 11.8 ℓ (721 cu. in.). The pipe wall is not included in the model. The bottom and top of each tank is a 28.575 cm (11.25 in.) diameter, 1.27 cm (1/2 in.) thick steel flange as measured in the fabrication shop (Attachment 5). There is a second flange on both the top and bottom used to hold the pipe in place, which is not included in the model.

---

[2] Pyrex is a registered trademark of Corning Glass Works

The feed tanks are positioned such that the vertical center line is 20 cm (8 in.) from the east wall. This is about 1.27 cm (1/2 in.) further from the wall than hand measurement indicates, but brings the tanks slightly closer to the calciner. The feed pump tank is modeled as being 109.5 cm (43 1/8 in.) from the south wall, and the feed receipt tank is modeled as being 40.01 cm (15 3/4 in.) from the south wall, as determined by scaling from a preliminary drawing (Attachment 4, Drawing A) and confirmation by hand measurement (Attachment 5). The bottom of the feed pump tank internal volume is 16.51 cm (6 1/2 in.) from the floor as determined by hand measurement, and the bottom of the internal volume for the feed receipt tank is 83.32 cm (33 in.) from the floor as determined by scaling from a preliminary drawing and confirmed by hand measurement.

Calculational models will include a 25.4 cm (10 in.) layer of plutonium precipitate on the bottom of each tank of fissile material as a normal condition, as this will be the administratively controlled limit. As the assumed density for this precipitate is 2 g Pu/cm^3, this represents a total of 9.8 kg of plutonium. A feed tank has a nominal capacity of 10 ℓ, which means that a feed tank completely filled with 450 g Pu/cm^3 feed solution holds a total of 4.5 kg. Furthermore, any significant buildup of solids on the bottom of the feed tanks will create problems in terms of clogging the system, requiring shutdown of the calciner operation until the solids are cleared.

4.4.2 Other Feed System Volumes

The waste section of the glovebox contains a vent catch tank, which collects liquid overflow from the feed system. Since the spent scrubber receipt tanks are modeled as being filled with feed solution in the calculation for Section 4.5.2, this is considered to bound the independent contingency of an overflow of a feed tank into the vent catch tank. A contingency concerning vacuum trap overflow into the vent tank is discussed further in the section on the scrubber system (Section 4.5.4).

All pumps in the glovebox have negligible holdup volume for the purpose of this analysis.

There is a flush tank connected to the feed pump that is used to facilitate restart after unplanned shutdown, and an air supply tank used to atomize feed solution for injection into the calciner. The flush tank has a nominal capacity of only 4 ℓ, the air supply has even less, and neither will contain fissile material under normal conditions. The off-normal condition of the scrubber tank filled with feed solution as described in Section 4.5.1, which represents an independent contingency, will bound any credible buildup of fissile material in these two tanks. Therefore, neither tank is included in the model.

4.4.3 Plutonium Concentration in Feed Solution

The maximum concentration administratively allowed in plutonium nitrate solutions is 450 g Pu/ℓ. Table III.A.4(95)-1 of ARH-600 (Carter, 1968) indicates that the concentration of minimum critical diameter for a fully reflected infinite cylinder is about 140 g Pu/ℓ. This corresponds to a plutonium nitrate density of 1.24 g/cm^3. Calculations as given in Table 9 show that the 140 g Pu/ℓ concentration is more reactive. This model represents a modification of the model for the calciner portion of the glovebox as described in Section 4.2.1.

Table 9. Variation in Reactivity as a Function of Feed Solution Concentration

Case	Feed Solution Concentration	k_{eff}	Std. Dev.
undert3	140 g Pu/ℓ	0.8929	0.0029
c450	450 g Pu/ℓ	0.8841	0.0029

The feed tanks as modeled do not have full reflection. For an unreflected infinite cylinder, Table III.A.4(95)-1 of ARH-600 (Carter, 1968) indicates a minimum critical diameter at about 130 g Pu/ℓ. However, as Table 9 of this section indicates, there would be little effect on reactivity for variations in concentration of this magnitude.

4.4.4 Double Batch of Plutonium Precipitates

The level of precipitates in the feed solution will effectively be zero under normal conditions, as the feed solution is mixed to avoid the formation of precipitation, and because the feed system within the glovebox will not operate due to plugging of the feed system to the calciner with any significant buildup of solids. As the allowed level of plutonium precipitate in each tank is 25.4 cm (10 in.), a double batch contingency would be to have a 50.8 cm (20 in.) layer of precipitate in both the feed pump and feed receipt tanks. The solids level in the scrubber tank is likewise increased to 50.8 cm (10 in.). As the density for precipitates as modeled is 2 g Pu/cm^3, the total plutonium mass for this level of solids is 19.6 kg for each tank, which is extremely conservative. To show that reactivity does not increase with a reduction in the level of plutonium precipitates in the tanks, a case is run with no precipitates. This model represents a modification of the model for the calciner portion of the glovebox as described in Section 4.2.1.

A doubling of solids in the tanks results in a small change in k_{eff} because the reactivity of the glovebox is primarily due to the product receiver vessels. This is demonstrated by case *df*. Case *df* differs from case *double*, only in that the calciner has been completely filled with product, and the off-gas filters in the calciner filled with feed solution. The calculated k_{eff} for case *df* is actually lower than case *double*, but within two sigma.

Table 10. Variation of Plutonium Precipitate Level

Case	Precipitate level	Product in Calciner	k_{eff}	Std. Dev.
zero	0	1.6 L	0.8871	0.0029
undert3	25.4 cm (10 in.)	1.6 L	0.8929	0.0029
double	50.8 cm (20 in.)	1.6 L	0.8942	0.0029
df	50.8 cm (20 in.)	full	0.8900	0.0029

4.5 SCRUBBER SYSTEM

The scrubber system is not expected to contain more than a token amount of fissile material (less than 0.01 g Pu/cm^3 of solution) under normal operating conditions. However, it is possible under abnormal conditions for this fissile concentration to be exceeded, although not to concentrations exceeding that of feed solution.

The bulk of the scrubber solution is contained within the scrubber tank in the calciner portion of the glovebox, and a set of tanks in the waste portion of the glovebox for storage of spent scrubber solution until the spent solution is sampled and removed from the glovebox. All tanks are made from the same 6 inch Pyrex® pipe used for construction of the feed tanks as described in Section 4.4.1.

4.5.1 Scrubber Tank

The scrubber tank is nominally 122 cm (48 in.) tall. The bottom of the scrubber tank internal volume is modeled as being 35.56 cm (14 in.) from the glovebox floor. Hand measurement indicates this distance is 34.29 cm (13 1/2 in.) (Attachment 5). However, the 1.27 cm (1/2 in.) difference will have little effect on reactivity.

In the case that the off-gas filters break, fissile concentration of the scrubber solution may increase, but not beyond the feed solution concentration of 450 g Pu/ℓ. To bound all accident conditions for a buildup of fissile concentration in the scrubber system, all cases were run with the scrubber full of feed solution, and a 25.4 cm (10 in.) layer of plutonium precipitate. Table 9 of Section 4.4.3 shows the results for both 140 g Pu/cm^3 and 450 g Pu/cm^3 solution.

4.5.2 Spent Scrubber Receipt Tanks

In the event that an abnormal amount of fissile material makes its way into the scrubber system, it would not necessarily be detected until it reaches the spent scrubber receipt tanks (SSRTs), where the solution is tested before removal from the glovebox. Calculations were made for the case that all the SSRTs used to contain spent scrubber solution are instead filled with feed solution and 25.4 cm (10 in.) of Pu solids as described in Section 4.1.4. Since only half of the tanks are used to receive spent scrubber solution at a time, to fill all tanks with abnormally high concentrations is considered conservatively bounding. Two container unit masses are assumed to be in this portion of the glovebox, with one unit mass under each of two cylinders for the SSRTs. These two unit masses each include an overbatch of one product receiver, for a total unit mass of 3 ℓ each. Results are given in Table 11 below. The product in the containers is 6.0 g Pu/cm^3, which is in excess of the density limit. This bounding case is within allowables.

Table 11. Feed Solution in Spent Scrubber Receipt Tanks

Case	Feed Solution Concentration	k_{eff}	Std. Dev.
waste	140 g Pu/ℓ	0.9009	0.0029
w450	450 g Pu/ℓ	0.8910	0.0029

4.5.3 Phase Separator Tank

The phase separator tank will contain some scrubber solution under normal operating conditions. The contingency of the phase separator tank filling with scrubber solution with abnormally high fissile content is considered.

PFD-Z-300-1 (Stubbs, 1997) lists the size of the phase separator tank as being 91.44 cm (36 in.) tall. It is positioned on the opposite side of the calciner from the scrubber and feed tanks. Although closer to the calciner than the scrubber tank, it has a smaller volume. One calculation was made to show that the contingency of a phase separator tank fully loaded with 140 g Pu/ℓ feed solution has little effect on reactivity. Table 12 shows a comparison between this case (*phase*) and the model it was derived from (case *down* in Section 4.3.4.1). The calciner insulation is dry in these cases in order to maximize interaction between the calciner and the phase separator tank in case *phase*. Case *pf* differs from case *phase* only in that the calciner is filled with product.

The phase separator was placed in the model of the calciner section of the glovebox with the vertical centerline 7.62 cm (3 in.) beyond the edge of this section. The artificial end of the calciner section model was moved back 30.48 cm (12 in.) to give room for the phase separator tank. The tank was also placed 20.32 cm (8 in.) from the west wall, as was done for the other tanks in the calciner section. Although preliminary drawings indicate that the bottom of the internal volume of the phase tank would be 70.49 cm (27 3/4 in.) from the glovebox floor, these same drawings indicate a 60.96 cm (48 in.) tall tank. Therefore, the bottom of the internal volume was moved down an additional 30.48 cm (12 in.) to be 40.01 cm (15 3/4 in.) from the floor to accommodate the longer length given in PFD-Z-300-001.

Table 12. Contribution of Phase Separator Tank to Reactivity

Case	Phase Separator with Feed Solution	Product in Calciner	k_{eff}	Std. Dev.
down	no	1.6 L	0.7606	0.0029
phase	yes	1.6 L	0.7731	0.0029
pf	yes	full	0.7885	0.0029

4.5.4 Other Scrubber System Volumes

With respect to the scrubber system, two contingencies would be required to fill the vacuum trap or vent catch tank with liquids with greater than a token amount of fissile material. The first would be the existence of scrubber solution with more than a token amount of fissile material concentration. The second would be the overflow of the phase separator tank. The vacuum trap and vent catch tanks are of much smaller volume than the scrubber tank and the spent scrubber receipt tanks, which are shown to be critically safe in Section 4.5.2, even when full of feed solution.

All pumps in the glovebox have negligible holdup volume for the purpose of this analysis.

4.6 CONTAINERS

There are three types of containers that will be allowed in the glovebox: product receiver vessels, 0.5 ℓ containers (1 pound slip lid cans and polyjars), and 30 mℓ sample jars. A limit requires that no more than two unit masses of 2 ℓ each be in the glovebox at one time. For the purpose of this limit, a product receiver vessel is considered 1 ℓ. The worst case position of the first unit is assumed to be under the calciner. The worst case position of the second unit mass is determined in Section 4.6.4. The models presented in this section represent modifications of the model for the calciner portion of the glovebox as described in Section 4.2.1.

4.6.1 Worst Case Unit Mass

The 0.5 ℓ (nominal) containers proposed for use in the HC-230C-2 glovebox are the 1 pound slip lid can (part number 42-1500-300) with the dimensions of 8.89 cm (3.5 in.) OD x 8.89 cm (3.5 in.) height, and the polyjar (part number 57-6359-160) with the dimensions of 8.255 cm (3.25 in.) OD x 10.16 cm (4 in.) height. The total internal volume for the 1 pound slip lid can is 552 mℓ, and for the polyjar it is 543 mℓ.

The internal dimensions for the product receiver vessel, which are taken from CSER 95-005 (Geiger, 1995a), are 4.445 cm (1 3/4 in.) radius x 15.24 cm (6 in.) height. The total internal volume for the product receiver vessel is 946 mℓ. This model for the product receiver vessel uses a flat bottom rather than a rounded bottom, which results in a larger modeled volume than the actual volume.

Note that the diameter of the product receiver vessel bounds the diameters of both the 1 pound slip lid can and the polyjar. For this reason, a unit mass was modeled as being two product receiver vessels, thus bounding any normal condition configuration for a unit mass. Although the contents of two 1 pound slip cans is 15% greater than that of a single product receiver vessel, two product receiver vessels side-by-side are assumed to be more reactive than four slip lid cans or a single product receiver vessel adjacent to two slip lid cans. Stacking of containers is not allowed, and is discussed as a contingency in Section 4.6.6.

4.6.2 Unit Attached to Calciner

It is assumed that the worst case position for one of the unit masses will be right beneath the calciner. One product receiver vessel may be attached to the bottom of the calciner at any time. This product receiver vessel is considered part of a unit mass beneath the calciner.

Table 13 shows that leaving the product receiver vessel with the unit mass on the floor is more reactive than leaving it attached to the calciner product drop tube in the two cases that were run. The first case (*down*) positions the product receiver vessel on the floor with the rest of the unit mass. In the case of *up*, the containers are up against the bottom of the calciner baseplate, even though the presence of hardware such as the feed solution injection system would disallow this. Neither case has water reflectors around the product receivers to represent hands of workers, and the insulation on the calciner is dry.

The unit mass considered consists of three product receiver vessels, constituting an overbatch contingency. The second unit mass is 25.4 cm (10 in.) away from the first in the direction of the scrubber tank. This model represents a modification of the model for the calciner portion of the glovebox as described in Section 4.2.1, excepting that the insulation on the calciner is dry, workers' hands are not included, and the product has a plutonium density of 6.5 g Pu/cm^3, which is substantially more conservative than the 5.5 g Pu/cm^3 limit for the calciner.

Table 13. Position of Product Receiver Vessel on Calciner Product Collection Tube

Case	Product	Position of Containers Under Calciner	k_{eff}	Std. Dev.
down	6.5 g Pu/cm^3, dry	Both on floor	0.7606	0.0029
up	6.5 g Pu/cm^3, dry	One against bottom of calciner base plate	0.7453	0.0029

4.6.3 Hands Around Containers

To study the effects of hands in the glovebox, case *wet* of Section 4.3.4.1 was modified to form a case *hand* by placing a 2.54 cm (1 in.) thick, close fitting annulus of water around every container. The containers each hold dry 6.5 g Pu/cm^3 product, which is substantially more conservative than the allowed density limit of 5.5 g Pu/cm^3 for the calciner. Table 14 shows how the presence of hands around containers can increase reactivity substantially. However, the hands as modelled are quite conservative by virtue of their size and number (one for each can). There are three product receivers in each unit mass, representing an overbatch contingency for each. The second unit mass was placed 25.4 cm (10 in.) away from the first unit mass towards the direction of the scrubber tank. The scrubber tank was modeled as being filled with feed solution as described in Section 4.5.1 above, and the calciner insulation is saturated with water.

Table 14. Effect of Hands Around Containers

Case	Hands Present	k_{eff}	Std. Dev.
wet	no	0.7686	0.0029
hand	yes	0.9035	0.0029

4.6.4 Worst Case Position of Second Unit Mass

To find the worst case position of the second unit on the glovebox floor, two cases were run. The first case (*hand*) considered the second unit 25.4 cm (10 in.) away from the first unit, which is under the calciner, in the direction of the scrubber tank filled with feed solution. The scrubber tank could have the largest volume of feed solution of any other tank in the calciner portion of the glovebox under an accident condition that allows feed solution to flow through the off-gas filters on the calciner (see Section 4.5.1 above). Other aspects of case *hand* are discussed in Section 4.6.3 above.

Case *undert* is the same as case *hand*, but the second unit is beneath the feed pump tank. The bottom of the feed pump tank sits only 6 3/8 in. from the floor, thus bringing the second unit as close as possible to a tank with feed solution while being on the glovebox floor. Table 15 shows how reactivity increases by positioning the second unit mass under the Feed Pump Tank. Both cases are for extra dense calcine (6.5 g Pu/cm^3) and an extra product receiver in every unit mass, representing multiple contingencies. That one case is just over the allowable shows the system to have a considerable margin of safety. The results in Table 16 show that the k_{eff} drops below 0.935 as the number of contingencies is reduced.

Table 15. Position of Second Unit mass (Includes Overbatching and 6.5 g Pu/cm^3 Product Density)

Case	Second Unit Position	k_{eff}	Std. Dev.
hand	Near scrubber	0.9035	0.0029
undert	Under feed pump tank	0.9354	0.0029

Table 16. Second Unit mass Under Feed Pump Tank

Case	Product Density (g Pu/cm^3)	Product Receiver Vessels Under Feed Tank	k_{eff}	Std. Dev.
undert3	6.0	3	0.8929	0.0029
undert4	6.5	2	0.8808	0.0029

Containers can be moved about freely in the glovebox as long as the maximum volume requirement and the appropriate spacing requirements between unit masses and the calciner are met. Additional cases were run to show the effect on reactivity when product receipt vessels are positioned adjacent to the 25.4 cm (10 in.) layer of plutonium precipitate in the feed pump tank.

The base case, *undert3*, considers three containers underneath the feed pump tank, representing an overbatch contingency. In case *next*, one product receiver vessel is moved up next to the layer of precipitates. In case *next2*, all three product receiver vessels are grouped around the Feed Pump tank as shown in Figure 1. In case *next3*, the three product receiver vessels are moved up such that two out of three of the product receiver vessels are next to the feed pump tank, and the third is placed adjacent to both of the first two units as shown in Figure 2. There are hands around all three containers in all the calculations. The results show that placing the unit mass beneath the feed pump tank, which also places it on top of the assumed layer of product on the bottom of the glovebox, is the worst case position for this second unit. This position for the second unit is used in the base model described in Section 4.1.3.

Table 17. Container Next to 25.4 cm (10 in.) Solids Layer in Feed Pump Tank

Case	Container Position	k_{eff}	Std. Dev.
undert3	Three containers beneath tank	0.8929	0.0029
next	One moved next to tank	0.8283	0.0029
next2	Second unit wrapped around tank (Figure 1)	0.8415	0.0029
next3	Second unit clustered next to tank (Figure 2)	0.8424	0.0029

Figure 1. Product Receiver Vessels Next to Solids in Feed Pump Tank (case *next2*)

```
W is water of hands
P is product in containers
S is Pu solids layer in feed tank

HORIZONTAL SCALE ----- 1 CHARACTER =  0.15385E+00
VERTICAL   SCALE ----- 1 LINE      =  0.25641E+00
```

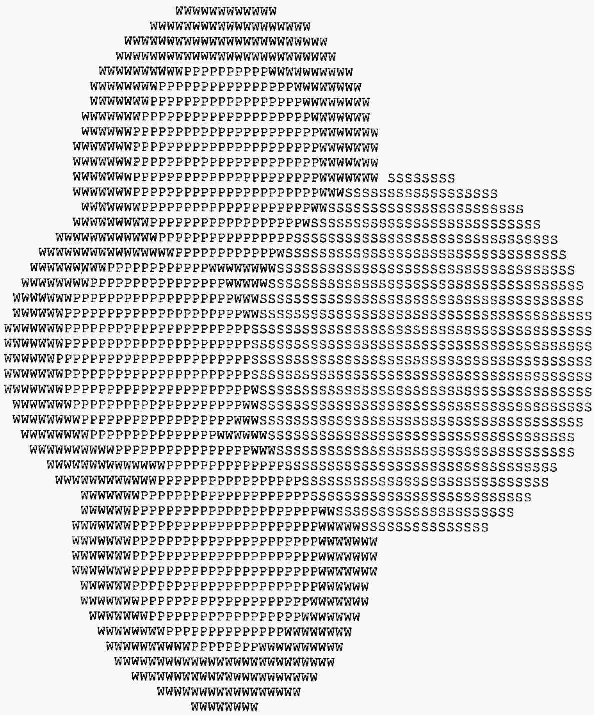
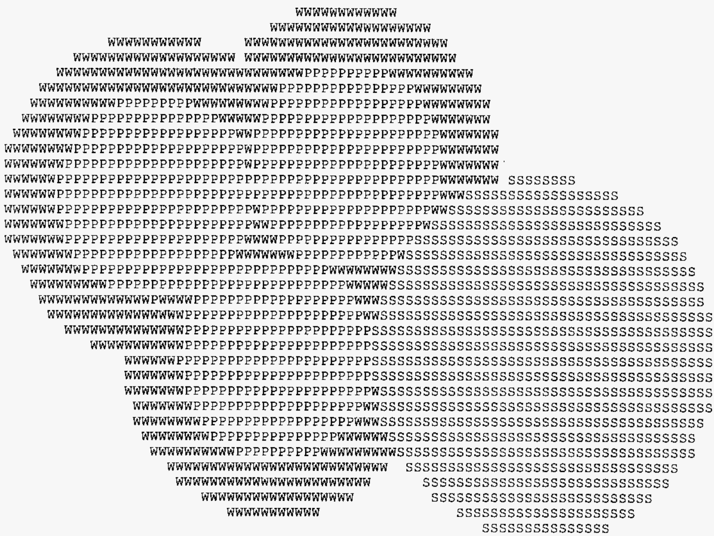


Figure 2. Product Receiver Vessels Clustered Next to Solids in Feed Pump Tank (case *next3*)

```
W is water of hands
P is product in containers
S is Pu solids layer in feed tank

HORIZONTAL SCALE ----- 1 CHARACTER =  0.15385E+00
VERTICAL   SCALE ----- 1 LINE      =  0.25641E+00
```



4.6.5 Container Overbatch

Case *undert3*, the base case for the calciner section of the glovebox as described in Section 4.2.1, includes two unit masses in the worst case positions in the glovebox, each unit mass consisting of three product receivers. As the maximum allowable unit mass size is 2 ℓ (the equivalent of two product receivers), this represents two overbatch contingencies. Additionally, the product is 6.0 g Pu/cm^3, representing another contingency of exceeding the product density limit. All the containers are surrounded by a 2.54 cm annulus of water, representing hands. The k_{eff} ● 1 σ is 0.8929 ± 0.0029, which is below the 0.935 limit for a single contingency.

4.6.6 Stacking of Containers

This contingency considers a worst case configuration of a unit mass by stacking containers. The worst case configuration for a unit mass including the contingency of stacking containers would be to create a stack of 1 pound slip lid cans. A stack of two slip lid cans is 15% taller than a single product receiver vessel.

Since there is not enough room beneath the feed pump tank to stack two slip lid cans, the second unit mass in this section is placed 25.4 cm (10 in.) from the first unit mass in the direction of the scrubber tank. Case *stack* was developed from case *hand* (section 4.6.3) to represent stacked containers by replacing each and every product receiver with a stack of two slip lid cans with 2.54 cm (1 in.) of close fitting water annuli around each the can. This case includes the contingencies of exceeding the product density limit of 5.5 g Pu/ℓ by using 6.5 g Pu/cm^3, multiple overbatching (3 ℓ in each unit mass), and multiple stacking. Even under these extreme conditions, the calculated $k_{eff} \pm 1\ \sigma$ is 0.9343 ± 0.0029, which is below the criticality safety limit. A second case was also run in which the calciner was filled with product. However, the $k_{eff} \pm 1\ \sigma$ for this case is 0.9315 ± 0.0029, which is within one sigma of case *stack*, indicating that reactivity is mostly due to the containers on the floor, as would be expected.

4.6.7 Placing a Container on the Lower Insulation

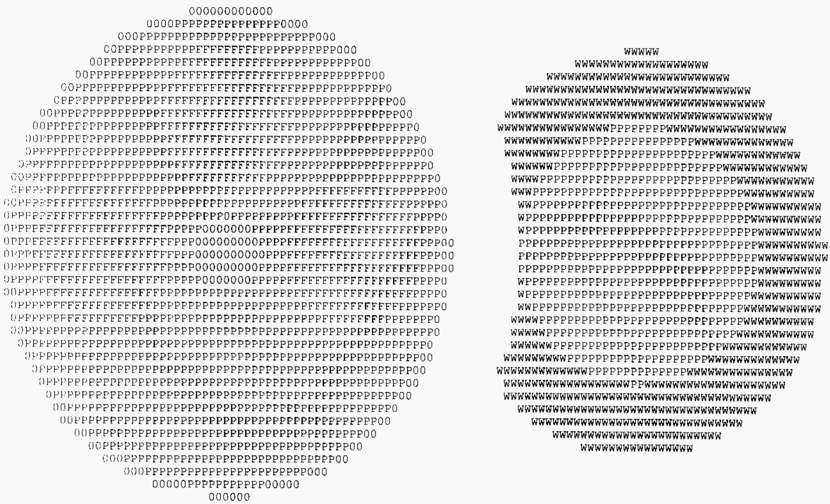
Case *onshelf* considers a the contingency of a full product receiver vessel placed on top of the lower insulation. The upper insulation was removed from the model to maximize interaction between the misplaced can and the fissile material inside the calciner. However, a 2.54 cm (1 in.) spacing between the can and the calciner vessel was used to represent the space taken by the upper insulation. There is also a 2.54 cm (1 in.) thick annulus of water representing hands. This arrangement is shown in Figure 3.

This case is a modification of case *nomist* from Section 4.2.6. As with case *nomist*, the calciner is filled with dry product. There are two product receiver vessels beneath the calciner, and two beneath the feed tank. Off-gas filters are filled with feed solution. There is also a layer of feed solution up to the level of the criticality drain. Feed solution on the glovebox floor and filling the off-gas filters with feed solution is not part of this contingency, but represents an additional conservatism. Additionally, all containers are surrounded by a 2.54 cm (1 in.) annulus of water representing hands, but not directly between the container and the calciner. All product, which includes the 0.9525 cm (3/8 in.) layer on the floor, the product in the containers, and the product in the calciner, is 6.0 g Pu/cm^3 and dry. With these contingencies and conservatisms, the $k_{eff} \pm 1\ \sigma$ for *onshelf* is 0.9029 ± 0.0029, which is below the criticality safety limit.

Figure 3. Model for Product Reciever Vessel on Lower Insulation

```
W is water of hands
P is product in containers
F is Off-Gas Filter
O is stainless steel

HORIZONTAL SCALE ----- 1 CHARACTER =  0.10385E+00
VERTICAL   SCALE ----- 1 LINE      =  0.17241E+00
```



5.0 REFERENCES

ANSWERS, 1992, *MONK6 - A Monte Carlo Code for Criticality Calculations*, Rev. 5, AEEW R2248, United Kingdom Atomic Energy Authority.

BWHC, 1997, Calciner Assembly, drawing #H-2-95609, Rev. 0, B & W Hanford Company, Richland, Washington.

Carter, R. D., G. R. Kiel and K. R. Ridgeway, 1968, *Criticality Handbook*, ARH-600, Atlantic Richfield Hanford Company, Richland, Washington.

Geiger, J. L., 1995a, *CSER 95-005: PFP Vertical Denitration Calciner*, ~~WHC-SD-SQA-20392,~~ WHC-SD-SQA-CSA-20392 KN Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Geiger, J. L., 1995b, *CSER 95-005 Addendum 1 Stainless Steel Insulation*, WHC-SD-SQA-CSA-20404, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Hammelman, J. E., 1974, *Z Plant Sprinkler System Criticality Safety Analysis Report*, ARH-2406, Rev. 0, Atlantic Richfield Hanford Company, Richland, Washington.

Lehmkuhl, G. D., 1974, *Criticality Drain Performance Study, RFP-2222, Dow Chemical U.S.A.*, Golden, Colorado.

LMI, 1996, *Series E7 Metering Pumps: Instructions, Maintenance, Service*, Liquid Metronics Division of Milton Leroy, Acton, Massachusetts.

Macklin, L. L., and E. M. Miller, 1992, *CCVR 91-001; MONK6A Pu Validation*, WHC-SD-SQA-CSWD-20015, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Miller, E. M., 1994a, *CCVR 94-001; MONK6B Pu Validation*, WHC-SD-SQA-CSWD-20019, Westinghouse Hanford Company, Richland, Washington.

Miller, E. M., 1994b, *CCVR 94-002; MONK6B - Software Quality Assurance Plan*, WHC-SD-SQA-CSWD-20017, Westinghouse Hanford Company, Richland, Washington.

Miller, E. M., 1997a, personal communication of E. M. Miller with G. S. Barney on May 2, 1997.

Miller, E. M., 1997b, personal communication of E. M. Miller with J. F. Durnil on June 5, 1997.

Stubbs, A.M., 1997, *Calcination of Plutonium Nitrate Solution, Plutonium Finishing Plant Process Flow Document PFD-Z-300-001*, Rev/Mod A-0, B & W Company, Richland, Washington.

Wittekind, W. D., 1997, *PFP Vertical Calciner Shield Wall Dose Rate Calculations Using MCNP*, HNF-SD-CP-TI-218, Rev. 0, Fluor Daniel Northwest, Inc., Richland, Washington.

APPENDIX A. INDEPENDENT REVIEW

E. M. Miller of the Criticality and Shielding group carried out an independent, technical review of CSER 97-004, for which the following comments were provided.

The CSER 97-004 found that the production denitration calciner glovebox has a k_{eff} of about 0.74 in a normal operating configuration with no hands in the glovebox. The k_{eff} is this low because the plutonium oxide product is dry and the feed solution is in geometrically favorable tanks. Increasing reflection to the calciner, to product receiver containers, or to the 6-inch tanks can substantially increase the reactivity of the glovebox. ARH-600 shows that for the plutonium density allowed in the tank solids, 2 g Pu/ℓ, mixed with water in the 6-inch tanks, that the tanks are substantially subcritical with no reflection, but critical with full reflection even with 5% Pu-240. The nitrate, limited height of solids allowed, the difficulty of getting solids of 2 g Pu/ℓ, and the difficulty in getting full water reflection make such an arrangement incredible, but the point is that operators should be aware that the addition of neutron reflecting materials, water of hands, polyethylene neutron shielding, or dense materials like lead or concrete should not be placed next to fissile material concentrations such as the feed tanks or product receiver containers.

The product receiver containers with dry product are safe even with the contingency of three product receiver containers adjacent with full water reflection. However, if water were to be added to wet the plutonium product in the product receiver containers, three containers with water or lead reflection may be critical per curves in ARH-600. Groupings of product receiver containers represent the largest possible concentration of fissile material in the calciner glovebox. Great care and thought needs to go into handling these containers.

This CSER has modelled the calciner conservatively. The calciner has a stirrer with a transition cone between stirring shaft and the top of the stirrer dome. The cone was not included in the calciner model in this CSER. So in cases of calcine and solution filling the calciner, a full diameter space above the stirring dome has fissile material where the actual calciner has a transition cone occupying the center of the space. This is the largest contiguous space for calcine inside the calciner model. Also, the absorbent lower insulation on the calciner is not as thick as modeled in the laboratory or production calciner. It is only about 4 inches thick. Because it is not as thick as modelled, it would not present as great a problem as was found for the thick models of the insulation when soaked with feed solution or as a reflector when modelled saturated with water.

The analysis of the calciner glovebox is conservative and shows that there are not any changes that raise reactivity rapidly. However, several limits need to be monitored and the results of actions understood. The density of the product needs to be monitored, spills of feed solution or product other than on the floor need to be cleaned up immediately, and the introduction of reflectors or moderators is to be prevented. Operators need to recognize that putting gloved hands around the product receiver containers increases its reactivity so that they will not circle more than one product container with hands and arms.

All k_{eff} results were confirmed and three MONK runs were examined in detail and found to conservatively represent the system being analyzed. The input data for materials and dimensions were checked and found to be correct or conservative. The glass of the 6-inch tanks was not included in the glovebox model which is conservative as the boron in the glass is an effective neutron absorber. The lack of glass would increase interaction while the effect of reflection by the glass would not be significant in comparison. The formula worksheets were checked and the calculation of H/Pu was corrected and revised H/Pu results included in the CSER. The dimensions of the off-gas filters, lower insulation, criticality drain, and calciner were revised or had uncertainties, but they were treated conservatively. Although many calculations were done with incorrect off-gas filter inside diameters, the actual dimensions of the off-gas filters were used where it would be significant, when the filters were flooded by feed solution.

The review of the CSER found that it covered all credible contingencies and showed that the system was within allowable limits and that there was sufficient margin of safety to have contingencies without being easily brought above allowables or to approach criticality. An example is that the allowable product density is limited to 5.5 g Pu/ℓ, but many of the analyses used higher densities and the results were within allowables. Although this variable needs to be monitored carefully, even with this parameter above its limit exceeding the allowable k_{eff} requires flooding the calciner filled with calcine with feed solution and also saturating the surrounding lower insulation with water. This is an extreme condition that includes the contingencies of a calciner filled with calcine, flooding the inside of the calciner with feed solution, and saturating the lower insulation outside the calciner with water.

The technical arguments for qualifying the criticality safety of the calciner glovebox were found to be sound. The report incorporates suggested changes and expansions made by the reviewer.

CHECKLIST FOR INDEPENDENT REVIEW

Document Reviewed: HNF-SD-SQA-CSA-529, Rev. 0, *CSER 97-004: PFP Production Denitration Calciner System*

Author: Karl E. Hillesland

Yes	No	N/A	
[X]	[ ]	[ ]	Problem completely defined.
[X]	[ ]	[ ]	Necessary assumptions explicitly stated and supported.
[X]	[ ]	[ ]	Computer codes and data files documented.
[X]	[ ]	[ ]	Data checked for consistency with original source information as applicable.
[X]	[ ]	[ ]	Mathematical derivations checked including dimensional consistency of results.
[X]	[ ]	[ ]	Models appropriate and used within range of validity or use outside range of established validity justified.
[X]	[ ]	[ ]	Hand calculations checked for errors.
[X]	[ ]	[ ]	Code run streams correct and consistent with analysis documentation.
[X]	[ ]	[ ]	Code output consistent with input and with results reported in analysis documentation.
[X]	[ ]	[ ]	Acceptability limits on analytical results applicable and supported. Limits checked against sources.
[X]	[ ]	[ ]	Safety margins consistent with good engineering practices.
[X]	[ ]	[ ]	Conclusions consistent with analytical results and applicable limits.
[X]	[ ]	[ ]	Results and conclusions address all points required in the problem statement.
[X]	[ ]	[ ]	Have all reasonable accidents been considered?
[X]	[ ]	[ ]	Has low density water (steam) been evaluated as a moderator?
[X]	[ ]	[ ]	Is the fuel and other hardware composition correct?
[X]	[ ]	[ ]	Are the cases considered conservative? Too conservative?
[X]	[ ]	[ ]	Do the computer models adequately reflect the actual geometry? Have cross sectional cuts of the geometry been made and do they show the desired geometry?
[X]	[ ]	[ ]	Has the analysis been reviewed by Safety? This may not be required in a preliminary design.
[X]	[ ]	[ ]	Has the reviewer completed the Criticality Safety Course for Managers and Engineers? Date completed 5/21/97

Reviewed by: Edward M. Miller *Edward M. Miller* Date 5/30/97

NOTE: Any hand calculations, notes, or summaries generated as part of this review should be signed, dated, and attached to this checklist. Materials should be labeled and recorded so that it is intelligible to a technically-qualified third party.

APPENDIX B. MONK VALIDATION

Validation Procedure

The validation of the method used in the analysis consists of testing the ability of the code and neutron cross-sections in calculation of known critical configurations, which are various benchmark experiments with the fissile material in question. Such analyses determine a calculational bias (the deviation of calculated k_{eff} from unity for the benchmark cases) and the uncertainties culminating from the experimental and calculational errors.

The safety criteria for future calculations on undetermined systems requires that the bias-adjusted k_{eff} does not exceed 0.95 at the 95% confidence interval. This is expressed by the following formula;

$$k_{eff} = k_{calc} - bias + (U_b^2 + U_c^2)^{\frac{1}{2}} \leq 0.95 \tag{1}$$

where:
k_{calc} = k value given by the calculation of the system
bias = mean difference (k_{calc}-1.0) for benchmark criticals
U_b = 95% confidence level uncertainty in bias determination
U_c = 95% confidence level uncertainty in new calculation.

Thus, the bias-adjusted k_{eff} includes the statistical uncertainties.

Generic Validation of Plutonium Systems

A report by L. L. Macklin and E. M. Miller (1992) presents the results of calculations to determine a generic bias for plutonium configurations, as encountered in the Plutonium Finishing Plant. Seventy benchmark experiments were calculated, ranging from simple metal spheres to highly diluted (9g plutonium per liter) plutonium nitrate solution spheres, and compacts of PuO_2 blended with polystyrene. A mean k_{eff} value of 1.0047 was determined over the full experimental range, with an average standard deviation of 0.0097.

The direct calculational bias is thus +0.0047 (average k_{eff} greater than unity). Accounting for the uncertainties using tolerance limit analysis, the report then concludes that

> At least 95% of all critical experiments of this type computed by the MONK6A code will produce calculated k_{eff} values greater than 0.9857 with 95% confidence.

For a standard deviation (σ) of 0.01 or less for the convergence of a future calculation (U_c), the 0.9857 value is lowered to 0.9855. Rounded conservatively, a value of +0.015 can be used for [-bias + $(U^2_b-U^2_c)^{1/2}$]. On this basis, it is determined that the true k_{eff} of an analyzed configuration with plutonium will not exceed 0.95 with a 95% confidence level if the calculated value (k_{calc}, $\sigma \leq 0.01$) is limited to a maximum of 0.935.

The 95% confidence level on 99.9% of the data is 0.9699. So a subcritical margin of 5% is 3.5% larger than the uncertainties between the 95.0% and the 99.9% coverage of the benchmark data.

Validation of MONK6B

The validation of MONK6B code on the SUN microcomputer was documented in Miller (1994a). The essence of the validation was cross-correlation of calculational results obtained with this code version and computer with results for identical model input done on a CRAY machine with MONK6A. Also, the equivalence of MONK6A and MONK6B was well documented by the vendor in the verification package shipped with the software.

References

Macklin, L. L., and E. M. Miller, 1992, *CCVR 91-001; MONK6A Pu Validation*, WHC-SD-SQA-CSWD-20015, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Miller, E. M., 1994a, *CCVR 94-001; MONK6B Pu Validation*, WHC-SD-SQA-CSWD-20019, Westinghouse Hanford Company, Richland, Washington.

Miller, E. M., 1994b, *CCVR 94-002; MONK6B - Software Quality Assurance Plan*, WHC-SD-SQA-CSWD-20017, Westinghouse Hanford Company, Richland, Washington.

APPENDIX C. WORKBOOK FOR CALCULATION OF MATERIAL COMPOSITIONS

Plutonium Oxide Composition Worksheet

	B	C	D	E	F	G	H
2	Fraction Pu241	0.02					
3	Fraction Pu240	0.05					
4	Fraction Pu239	0.93					
5	All atomic weights from CRC			Theoretical density of PuO2	11.46	g/cc	ARH-600
6	Pu241	241.0568		Theoretical density of Pu(NO3)4	5.629	g/cc	ARH-600
7	Pu240	240.0538		Density Pu in PuO2	5.5	g/cc	given
8	Pu239	239.0522		Density of PuO2	6.235936	g/cc	calculated
9	Total Pu	239.1423		Volume fraction occupied by PuO2 at theoretical density	0.544148		
10	O	15.9994		Remaining volume fraction	0.455852		
11	H	1.0079		Mass of Pu nitrate in unit volume	2.565991	g	
12	PuO2	271.1411		Total density	8.801927	g/cc	
13	H2O	18.0152		Mass fraction PuO2	0.708474		
14	N	14.00674		Mass fraction Pu nitrate	0.291526		
15	Pu(NO3)4	487.1621		Pu in mud	6.759616	g/cc	
16				Density of Pu in Pu(NO3)4	2.763212	g Pu/cc	
17							
18	Mass fractions						
19	Fraction Pu in PuO2	0.881985		Mass of H2O in unit volume	0.455852	g	
20	Fraction Pu in Pu(NO3)4	0.490889		Total density	6.691788	g/cc	
21	Fraction H in H2O	0.111894		Water density			
22	Fraction O in PuO2	0.118015		H/Pu	2.200435		
23	Fraction O in H2O	0.888106					
24				Mass Pu in mud (water)	5.5		
25				Mass O in mud	1.140781		
26				Mass H in mud	0.051007		
27				total	6.691788		
28							
29				Mass Pu241 in mud	0.11		
30				Mass Pu240 in mud	0.275		
31				Mass Pu239 in mud	5.115		
32							
33				Mass O in dry PuO2	0.735936		

	I	J	K	L
7	Density Pu in PuO2	6	4	2
8	Density of PuO2	6.802839	4.535226	2.267613
9	Volume fraction occupied by PuO2 at theoretical density	0.593616	0.395744	0.197872
10	Remaining volume fraction	0.406384	0.604256	0.802128
11				
12				
13				
14				
15				
16				
17				
18				
19	Mass of H2O in unit volume	0.2	0.604256	0.802128
20	Total density	7.002839	5.139482	3.069741
21				
22	H/Pu	0.884965	4.010591	10.64783
23				
24	Mass Pu in mud (water)	6	4	2
25	Mass O in mud	0.98046	1.071869	0.979987
26	Mass H in mud	0.022379	0.067613	0.089754
27				
28				
29	Mass Pu241 in mud	0.12	0.08	0.04
30	Mass Pu240 in mud	0.3	0.2	0.1
31	Mass Pu239 in mud	5.58	3.72	1.86

Plutonium Oxide Composition Worksheet (Formulas)

	B	C	D	E	F	G	H
2	Fraction Pu241	=0.02					
3	Fraction Pu240	0.05					
4	Fraction Pu239	=1-$C$3-$C$2					
5	All atomic weights from CRC			Theoretical density of PuO2	11.46	g/cc	ARH-600
6	Pu241	241.056845		Theoretical density of Pu(NO3)4	5.629	g/cc	ARH-600
7	Pu240	240.053808		Density Pu in PuO2	5.5	g/cc	given
8	Pu239	239.052157		Density of PuO2	=$F$7*($C$9+2*$C$10)/$C$9	g/cc	calculated
9	Total Pu	=$C$2*$C$6+$C$3*$C$7+$C$4*$C$8		Volume fraction occupied by PuO2 at theoretical density	=$F$8/$F$5		
10	O	15.9994		Remaining volume fraction	=1-$F$9		
11	H	1.0079		Mass of Pu nitrate in unit volume	=$F$10*$F$6	g	
12	PuO2	=C9+C10*2		Total density	=$F$8+$F$11	g/cc	
13	H2O	=C11*2+C10		Mass fraction PuO2	=$F$8/$F$12		
14	N	14.00674		Mass fraction Pu nitrate	=$F$11/$F$12		
15	Pu(NO3)4	=$C$9+4*($C$14+3*$C$10)		Pu in mud	=$F$7+$F$11*$C$20	g/cc	
16				Density of Pu in Pu(NO3)4	=$C$20*$F$6	g Pu/cc	
17							
18	Mass fractions						
19	Fraction Pu in PuO2	=$C$9/$C$12		Mass of H2O in unit volume	=$F$10	g	
20	Fraction Pu in Pu(NO3)4	=$C$9/$C$15		Total density	=$F$8+$F$19	g/cc	
21	Fraction H in H2O	=2*C11/C13		Water density			
22	Fraction O in PuO2	=2*$C$10/$C$12		H/Pu	=($F$19/$C$13*2)/($F$7/$C$9)		
23	Fraction O in H2O	=$C$10/$C$13					
24				Mass Pu in mud (water)	=$F$7		
25				Mass O in mud	=$F$8*$C$22+$F$19*$C$23		
26				Mass H in mud	=$F$19*$C$21		
27				total	=SUM($F$24:$F$26)		
28							
29				Mass Pu241 in mud	=$C$2*$F$24		
30				Mass Pu240 in mud	=$C$3*$F$24		
31				Mass Pu239 in mud	=$C$4*$F$24		
32							
33				Mass O in dry PuO2	=$F$8*$C$22		

	I	J	K	L
7	Density Pu in PuO2	6	4	2
8	Density of PuO2	=J$7*($C$9+2*$C$10)/$C$9	=K$7*($C$9+2*$C$10)/$C$9	=L$7*($C$9+2*$C$10)/$C$9
9	Volume fraction occupied by PuO2 at theoretical density	=J$8/$F$5	=K$8/$F$5	=L$8/$F$5
10	Remaining volume fraction	=1-J$9	=1-K$9	=1-L$9
11				
12				
13				
14				
15				
16				
17				
18				
19	Mass of H2O in unit volume	0.2	=K10	=L10
20	Total density	=J$8+J$19	=K$8+K$19	=L$8+L$19
21				
22	H/Pu	=(J$19/$C$13*2)/(J$7/$C$9)	=(K$19/$C$13*2)/(K$7/$C$9)	=(L$19/$C$13*2)/(L$7/$C$9)
23				
24	Mass Pu in mud (water)	=J$7	=K$7	=L$7
25	Mass O in mud	=J$8*$C$22+J$19*$C$23	=K$8*$C$22+K$19*$C$23	=L$8*$C$22+L$19*$C$23
26	Mass H in mud	=J$19*$C$21	=K$19*$C$21	=L$19*$C$21
27				
28				
29	Mass Pu241 in mud	=$C$2*J$24	=$C$2*K$24	=$C$2*L$24
30	Mass Pu240 in mud	=$C$3*J$24	=$C$3*K$24	=$C$3*L$24
31	Mass Pu239 in mud	=$C$4*J$24	=$C$4*K$24	=$C$4*L$24

Nitrate Composition Worksheet

	A	B	C	D	E	F	G	H
1		Fraction Pu241	0.02					
2		Fraction Pu240	0.05					
3		Fraction Pu239	0.93					
4		All atomic weights from CRC						
5		Pu241	241.0568		Theoretical density of Pu(NO3)4	5.629	g/cc	ARH-600
6		Pu240	240.0538		Pu concentration	450	g Pu/L	given
7		Pu239	239.0522			0.45	g/cc	
8		Total Pu	239.1423		Pu(NO3)4 concentration	0.916705	g/cc	
9		O	15.9994		Volume of Pu nitrate in 1 cc of solution	0.162854	cc	
10		H	1.0079		Volume of water in 1 cc of solution	0.837146	cc	
11		PuO2	271.1411		Water concentration	0.837146	g/cc	
12		H2O	18.0152		Total density	1.753851	g/cc	
13		N	14.00674					
14		Pu(NO3)4	487.1621		Mass Pu	0.45	g/cc	
15		Mass fractions			Mass N	0.105427	g/cc	
16		Fraction Pu in PuO2	0.881985		Mass O	1.104752	g/cc	
17		Fraction Pu in Pu(NO3)4	0.490889		Mass H	0.093672	g/cc	
18		Fraction H in H2O	0.111894		total	1.753851	g/cc	
19		Fraction N in Pu nitrate	0.115007					
20		Fraction O in Pu nitrate	0.394105		Mass Pu241	0.009		
21		Fraction O in H2O	0.888106		Mass Pu240	0.0225		
22		Fraction O in PuO2	0.118015		Mass Pu239	0.4185		
23							g/cc	ARH-600
24					Theoretical density of PuO2	11.46	g/cc	given
25					Density Pu in PuO2	5.5	g/cc	
26					Density of PuO2	6.235936	cc	
27					Volume of PuO2 in 1 cc of mud	0.544148	cc	
28					Volume of solution in 1 cc of mud	0.455852	g/cc	
29					Solution concentration (in mud)	0.799496	g/cc	
30					Total density	7.035432		
31							g/cc	
32					Mass Pu	5.705133	g/cc	
33					Mass O	1.239539	g/cc	
34					Mass N	0.048059	g/cc	
35					Mass H	0.042701	g/cc	
36					total	7.035432		
37								
38					Mass Pu241	0.114103		
39					Mass Pu240	0.285257		
40					Mass Pu239	5.305774		
41								
42					H/Pu	1.775852		

Nitrate Composition Worksheet (Formulas)

	A	B	C	D	E	F
1		Fraction Pu241	0.02			
2		Fraction Pu240	0.05			
3		Fraction Pu239	=1-($C$1+$C$2)			
4		All atomic weights from CRC				
5		Pu241	241.056845		Theoretical density of Pu(NO3)4	5.629
6		Pu240	240.053808		Pu concentration	450
7		Pu239	239.052157			=$F$6/1000
8		Total Pu	=$C$1*$C$5+$C$2*$C$6+$C$3*$C$7		Pu(NO3)4 concentration	=$F$7/$C$17
9		O	15.9994		Volume of Pu nitrate in 1 cc of solution	=$F$8/$F$5
10		H	1.0079		Volume of water in 1 cc of solution	=1-$F$9
11		PuO2	=C8+C9*2		Water concentration	=$F$10
12		H2O	=C10*2+C9		Total density	=$F$8+$F$11
13		N	14.00674			
14		Pu(NO3)4	=$C$8+4*($C$13+3*$C$9)		Mass Pu	=$F$8*$C$17
15		Mass fractions			Mass N	=$F$8*$C$19
16		Fraction Pu in PuO2	=$C$8/$C$11		Mass O	=$F$8*$C$20+$F$11*$C$21
17		Fraction Pu in Pu(NO3)4	=$C$8/$C$14		Mass H	=$F$11*$C$18
18		Fraction H in H2O	=2*C10/C12		total	=SUM($F$14:$F$17)
19		Fraction N in Pu nitrate	=4*$C$13/$C$14			
20		Fraction O in Pu nitrate	=12*$C$9/$C$14		Mass Pu241	=$C$1*$F$14
21		Fraction O in H2O	=$C$9/$C$12		Mass Pu240	=$C$2*$F$14
22		Fraction O in PuO2	=2*$C$9/$C$11		Mass Pu239	=$C$3*$F$14
23						
24					Theoretical density of PuO2	11.46
25					Density Pu in PuO2	5.5
26					Density of PuO2	=$F$25/$C$16
27					Volume of PuO2 in 1 cc of mud	=$F$26/$F$24
28					Volume of solution in 1 cc of mud	=1-$F$27
29					Solution concentration (in mud)	=$F$12*$F$28
30					Total density	=$F$26+$F$29
31						
32					Mass Pu	=$F$25+$F$29/$F$12*$F$14
33					Mass O	=$F$26*$C$22+$F$29/$F$12*$F$16
34					Mass N	=$F$29/$F$12*$F$15
35					Mass H	=$F$29/$F$12*$F$17
36					total	=SUM(F32:F35)
37						
38					Mass Pu241	=$C$1*$F$32
39					Mass Pu240	=$C$2*$F$32
40					Mass Pu239	=$C$3*$F$32
41						
42					H/Pu	=F35/C10/(F32/(C1*C5+C2*C6+C3*C7))

Plutonium Solution Composition Worksheet

	B	C	D	E	F	G	H	I	J	K	L	M	N
1	Fraction Pu241	0.02											
2	Fraction Pu240	0.05											
3	Fraction Pu239	0.93											
4	All atomic weights from CRC												
5	Pu241	241.0568		Theoretical density of Pu	19.76745	g/cc	ARH-600						
6	Pu240	240.0538		Pu concentration	450	g Pu/L	given						
7	Pu239	239.0522			0.45	g/cc							
8	Total Pu	239.1423		Pu concentration in Pu solution	0.45	g/cc							
9	O	15.9994		Volume of Pu in 1 cc of solution	0.022765	cc							
10	H	1.0079		Volume of water in 1 cc of solution	0.977235	cc							
11	PuO2	271.1411		Water concentration	0.977235	g/cc							
12	H2O	18.0152		Total density	1.427235	g/cc							
13													
14				Mass Pu	0.45	g/cc							
15	Mass fractions			Mass O	0.867888	g/cc							
16	Fraction Pu in PuO2	0.881985		Mass H	0.109347	g/cc							
17				total	1.427235	g/cc							
18	Fraction H in H2O	0.111894											
19	Fraction O in H2O	0.888106		Mass Pu241	0.009								
20	Fraction O in PuO2	0.118015		Mass Pu240	0.0225								
21				Mass Pu239	0.4185								
22													
23				H/Pu ratio	57.65461								
24									full saturation		solution	solution	solution
25				Theoretical density of PuO2	11.46	g/cc	ARH-600				removed	removed	removed
26				Density Pu in PuO2	5.5	g/cc	given		5	2	6	6	6
27				Density of PuO2	6.235936	g/cc			5.669033	2.267613	6.802839	6.802839	6.802839
28				Volume of PuO2 in 1 cc of mud	0.544148	g/cc			0.49468	0.197872	0.593616	0.593616	0.593616
29				Volume of solution in 1 cc of mud	0.455852	cc			0.50532	0.802128	0.1	0.2	0.3
30				Solution concentration (in mud)	0.650608	g/cc			0.721211	1.144825	0.142724	0.285447	0.428171
31				Total density	6.886544	g/cc		Total density	6.390243	3.412438	6.945563	7.088286	7.23101
32													
33				Mass Pu	5.705133	g/cc		Mass Pu	5.227394	2.360958	6.045	6.09	6.135
34				Mass O	1.131564	g/cc		Mass O	1.107594	0.96377	0.889628	0.976417	1.063205
35				Mass H	0.049846	g/cc		Mass H	0.055255	0.08771	0.010935	0.021869	0.032804
36				total	6.886544	g/cc			6.390243	3.412438	6.945563	7.088286	7.23101
37													
38				Mass Pu241	0.114103			Mass Pu241	0.104548	0.047219	0.1209	0.1218	0.1227
39				Mass Pu240	0.285257			Mass Pu240	0.26137	0.118048	0.30225	0.3045	0.30675
40				Mass Pu239	5.305774			Mass Pu239	4.861476	2.195691	5.62185	5.6637	5.70555
41													
42				H/Pu ratio	2.073025			H/Pu ratio	2.508001	8.814588	0.429191	0.852039	1.268683

Plutonium Solution Composition Worksheet (Formulas)

	B	C	E	F
1	Fraction Pu241	0.02		
2	Fraction Pu240	0.05		
3	Fraction Pu239	=1-($C$1+$C$2)		
4	All atomic weights from CRC			
5	Pu241	241.056845	Theoretical density of Pu	=19.76/$C$7*$C$8
6	Pu240	240.053808	Pu concentration	450
7	Pu239	239.052157		=$F$6/1000
8	Total Pu	=$C$1*$C$5+$C$2*$C$6+$C$3*$C$7	Pu concentration in Pu solution	=F7
9	O	15.9994	Volume of Pu in 1 cc of solution	=$F$8/$F$5
10	H	1.0079	Volume of water in 1 cc of solution	=1-$F$9
11	PuO2	=C8+C9*2	Water concentration	=$F$10
12	H2O	=C10*2+C9	Total density	=$F$8+$F$11
13				
14			Mass Pu	=$F$8
15	Mass fractions		Mass O	=$F$11*$C$19
16	Fraction Pu in PuO2	=$C$8/$C$11	Mass H	=$F$11*$C$18
17			total	=SUM($F$14:$F$16)
18	Fraction H in H2O	=2*C10/C12		
19	Fraction O in H2O	=$C$9/$C$12	Mass Pu241	=$C$1*$F$14
20	Fraction O in PuO2	=2*$C$9/$C$11	Mass Pu240	=$C$2*$F$14
21			Mass Pu239	=$C$3*$F$14
22				
23			H/Pu ratio	=($F$16/$C$10)/(0.45/$C$8)
24				
25			Theoretical density of PuO2	11.46
26			Density Pu in PuO2	5.5
27			Density of PuO2	=$F$26/$C$16
28			Volume of PuO2 in 1 cc of mud	=$F$27/$F$25
29			Volume of solution in 1 cc of mud	=1-$F$28
30			Solution concentration (in mud)	=$F$12*$F$29
31			Total density	=$F$27+$F$30
32				
33			Mass Pu	=$F$26+$F$30/$F$12*$F$14
34			Mass O	=$F$27*$C$20+$F$30/$F$12*$F$15
35			Mass H	=$F$30/$F$12*$F$16
36			total	=SUM(F33:F35)
37				
38			Mass Pu241	=$C$1*$F$33
39			Mass Pu240	=$C$2*$F$33
40			Mass Pu239	=$C$3*$F$33
41				
42			H/Pu ratio	=($F$35/$C$10)/($F$33/$C$8)

	I	J	K	L	M	N
24		full saturation		solution	solution	solution
25				removed	removed	removed
26		5	2	6	6	6
27		=J$26/$C$16	=K$26/$C$16	=L$26/$C$16	=M$26/$C$16	=N$26/$C$16
28		=J$27/$F$25	=K$27/$F$25	=L$27/$F$25	=M$27/$F$25	=N$27/$F$25
29		=1-J$28	=1-K$28	0.1	0.2	0.3
30		=$F$12*J$29	=$F$12*K$29	=$F$12*L$29	=$F$12*M$29	=$F$12*N$29
31	Total density	=J$27+J$30	=K$27+K$30	=L$27+L$30	=M$27+M$30	=N$27+N$30
32						
33	Mass Pu	=J$26+J$30/$F$12*$F$14	=K$26+K$30/$F$12*$F$14	=L$26+L$30/$F$12*$F$14	=M$26+M$30/$F$12*$F$14	=N$26+N$30/$F$12*$F$14
34	Mass O	=J$27*$C$20+J$30/$F$12*$F$15	=K$27*$C$20+K$30/$F$12*$F$15	=L$27*$C$20+L$30/$F$12*$F$15	=M$27*$C$20+M$30/$F$12*$F$15	=N$27*$C$20+N$30/$F$12*$F$15
35	Mass H	=J$30/$F$12*$F$16	=K$30/$F$12*$F$16	=L$30/$F$12*$F$16	=M$30/$F$12*$F$16	=N$30/$F$12*$F$16
36		=SUM(J33:J35)	=SUM(K33:K35)	=SUM(L33:L35)	=SUM(M33:M35)	=SUM(N33:N35)
37						
38	Mass Pu241	=$C$1*J$33	=$C$1*K$33	=$C$1*L$33	=$C$1*M$33	=$C$1*N$33
39	Mass Pu240	=$C$2*J$33	=$C$2*K$33	=$C$2*L$33	=$C$2*M$33	=$C$2*N$33
40	Mass Pu239	=$C$3*J$33	=$C$3*K$33	=$C$3*L$33	=$C$3*M$33	=$C$3*N$33
41						
42	H/Pu ratio	=(J$35/$C$10)/(J33/$C$8)	=(K$35/$C$10)/(K33/$C$8)	=(L$35/$C$10)/(L33/$C$8)	=(M$35/$C$10)/(M33/$C$8)	=(N$35/$C$10)/(N33/$C$8)

Soaked Lower Insulation Composition Worksheet

	A	B	C	D	E	F	G	H
1		Fraction Pu241	0.02					
2		Fraction Pu240	0.05					
3		Fraction Pu239	0.93					
4		All atomic weights from CRC						
5		Pu241	241.0568		Theoretical density of Pu	19.76745	g/cc	ARH-600
6		Pu240	240.0538		Pu concentration	450	g Pu/L	given
7		Pu239	239.0522			0.45	g/cc	
8		Total Pu	239.1423		Pu concentration in Pu solution	0.45	g/cc	
9		O	15.9994		Volume of Pu in 1 cc of solution	0.022765	cc	
10		H	1.0079		Volume of water in 1 cc of solution	0.977235	cc	
11		Si	28.0855		Water concentration	0.977235	g/cc	
12		AL27	26.98154		Total density	1.427235	g/cc	
13		H2O	18.0152					
14					Mass Pu	0.45	g/cc	
15		MASS FRACTIONS			Mass O	0.867888	g/cc	
16					Mass H	0.109347	g/cc	
17		Fraction H in H2O	0.111894		total	1.427235	g/cc	
18		Fraction O in H2O	0.888106					
19					Mass Pu241	0.009		
20		Avogadro from CRC (in 1E24)	0.602214		Mass Pu240	0.0225		
21					Mass Pu239	0.4185		
22								
23					H/Pu ratio	57.65461		
24								
25								
26					The insulation composition is based on Addendum 1			
27					monk input, material 4, "soaked insulation"			
28					Water must first be removed to find the actual insulation used.			
29					The original CSER did not have AL in it, although it does contain			
30					dry insulation.			
31								
32					H in soaked insulation	0.060168	atoms/barn-cm	
33					Total O in insulation	0.036967	atoms/barn-cm	
34					O after water removal	0.006883	atoms/barn-cm	
35					Si in insulation	0.000109	atoms/barn-cm	
36					AL27 in insulation	0.004443	atoms/barn-cm	
37								
38					MASS			
39					O	1.598522		
40					Si	1.724034		
41					AL27	0.308385		
42								
43					TOTAL			
44					Pu239	0.37665		
45					Pu240	0.02025		
46					Pu241	0.0081		
47					H	0.098412		
48					O	0.940952		
49					Si	0.172403		
50					AL27	0.030839		
51								
52					TOTAL	1.647606		

Soaked Lower Insulation Composition Worksheet (Formulas)

	B	C	D	E	F
1	Fraction Pu241	0.02			
2	Fraction Pu240	0.05			
3	Fraction Pu239	=1-($C$1+$C$2)			
4	All atomic weights from CRC				
5	Pu241	241.056845		Theoretical density of Pu	=19.76/$C$7*$C$8
6	Pu240	240.053808		Pu concentration	450
7	Pu239	239.052157			=$F$6/1000
8	Total Pu	=$C$1*$C$5+$C$2*$C$6+$C$3*$C$7		Pu concentration in Pu solution	=F7
9	O	15.9994		Volume of Pu in 1 cc of solution	=$F$8/$F$5
10	H	1.0079		Volume of water in 1 cc of solution	=1-$F$9
11	Si	28.0855		Water concentration	=$F$10
12	AL27	26.981539		Total density	=$F$8+$F$11
13	H2O	=C10*2+C9			
14				Mass Pu	=$F$8
15	MASS FRACTIONS			Mass O	=$F$11*$C$18
16				Mass H	=$F$11*$C$17
17	Fraction H in H2O	=2*C10/C13		total	=SUM($F$14:$F$16)
18	Fraction O in H2O	=$C$9/$C$13			
19				Mass Pu241	=$C$1*$F$14
20	Avogadro from CRC (in 1E24)	0.60221367		Mass Pu240	=$C$2*$F$14
21				Mass Pu239	=$C$3*$F$14
22					
23				H/Pu ratio	=($F$16/$C$10)/(0.45/$C$8)
24					
25					
26				The insulation composition is based on Addendum 1	
27				monk input, material 4, "soaked insulation"	
28				Water must first be removed to find the actual insulation used.	
29				The original CSER did not have AL in it, although it does contain	
30				dry insulation.	
31					
32				H in soaked insulation	0.060168
33				Total O in insulation	0.036967
34				O after water removal	=F33-F32/2
35				Si in insulation	0.000109
36				AL27 in insulation	0.004443
37					
38				MASS	
39				O	=F32*C9/$C$20
40				Si	=F33*C11/$C$20
41				AL27	=F34*C12/$C$20
42					
43				TOTAL	
44				Pu239	=0.9*F21
45				Pu240	=0.9*F20
46				Pu241	=0.9*F19
47				H	=0.9*F16
48				O	=0.9*F15+0.1*F39
49				Si	=0.1*F40
50				AL27	=0.1*F41
51					
52				TOTAL	=SUM(F44:F50)

Upper Insulation Composition Worksheet

	B	C	D	E	F	G	H
1	Fraction Pu241	0.02					
2	Fraction Pu240	0.05					
3	Fraction Pu239	0.93					
4	All atomic weights from CRC						
5	Pu241	241.0568		Theoretical density of Pu	19.76745	g/cc	ARH-600
6	Pu240	240.0538		Pu concentration	450	g Pu/L	given
7	Pu239	239.0522			0.45	g/cc	
8	Total Pu	239.1423		Pu concentration in Pu solution	0.45	g/cc	
9	O	15.9994		Volume of Pu in 1 cc of solution	0.022765	cc	
10	H	1.0079		Volume of water in 1 cc of solution	0.977235	cc	
11	Fe	55.847		Water concentration	0.977235	g/cc	
12	Cr	51.9961		Total density	1.427235	g/cc	
13	Ni	58.6934					
14	H2O	18.0152		Mass Pu	0.45	g/cc	
15				Mass O	0.867888	g/cc	
16	MASS FRACTIONS			Mass H	0.109347	g/cc	
17				total	1.427235	g/cc	
18	Fraction H in H2O	0.111894					
19	Fraction O in H2O	0.888106		Mass Pu241	0.009		
20				Mass Pu240	0.0225		
21	Avogadro from CRC (in 1E24)	0.602214		Mass Pu239	0.4185		
22							
23				H/Pu ratio	57.65461		
24							
25							
26				The insulation composition is based on 10% density			
27				304 SST from ARH-600			
28							
29				Fe	0.06331	atoms/barn-cm	
30				Cr	0.01654	atoms/barn-cm	
31				Ni	0.00651	atoms/barn-cm	
32							
33				MASS			
34				Fe	5.871128		
35				Cr	1.42809		
36				Ni	0.634482		
37				Total	7.933701		
38							
39				TOTAL			
40				Pu239	0.04185		
41				Pu240	0.00225		
42				Pu241	0.0009		
43				H	0.010935		
44				O	0.086789		
45				Fe	0.587113		
46				Cr	0.142809		
47				Ni	0.063448		
48							
49				TOTAL	0.872645		
50							
51				WATER VERSION			
52				Fe	0.587113		
53				Cr	0.142809		
54				Ni	0.063448		
55				H	0.011189		
56				O	0.088811		
57							
58				TOTAL	0.89337		

Upper Insulation Composition Worksheet (Formulas)

	B	C	D	E	F
1	Fraction Pu241	0.02			
2	Fraction Pu240	0.05			
3	Fraction Pu239	=1-($C$1+$C$2)			
4	All atomic weights from CRC				
5	Pu241	241.056845		Theoretical density of Pu	=19.76/$C$7*$C$8
6	Pu240	240.053808		Pu concentration	450
7	Pu239	239.052157			=$F$6/1000
8	Total Pu	=$C$1*$C$5+$C$2*$C$6+$C$3*$C$7		Pu concentration in Pu solution	=F7
9	O	15.9994		Volume of Pu in 1 cc of solution	=$F$8/$F$5
10	H	1.0079		Volume of water in 1 cc of solution	=1-$F$9
11	Fe	55.847		Water concentration	=$F$10
12	Cr	51.9961		Total density	=$F$8+$F$11
13	Ni	58.6934			
14	H2O	=C10*2+C9		Mass Pu	=$F$8
15				Mass O	=$F$11*$C$19
16	MASS FRACTIONS			Mass H	=$F$11*$C$18
17				total	=SUM($F$14:$F$16)
18	Fraction H in H2O	=2*C10/C14			
19	Fraction O in H2O	=$C$9/$C$14		Mass Pu241	=$C$1*$F$14
20				Mass Pu240	=$C$2*$F$14
21	Avogadro from CRC (in 1E24)	0.60221367		Mass Pu239	=$C$3*$F$14
22					
23				H/Pu ratio	=($F$16/$C$10)/(0.45/$C$8)
24					
25					
26				The insulation composition is based on 10% density	
27				304 SST from ARH-600	
28					
29				Fe	0.06331
30				Cr	0.01654
31				Ni	0.00651
32					
33				MASS	
34				Fe	=F29*C11/$C$21
35				Cr	=F30*C12/$C$21
36				Ni	=F31*C13/$C$21
37				Total	=SUM(F34:F36)
38					
39				TOTAL	
40				Pu239	=0.1*F21
41				Pu240	=0.1*F20
42				Pu241	=0.1*F19
43				H	=0.1*F16
44				O	=0.1*F15
45				Fe	=0.1*F34
46				Cr	=0.1*F35
47				Ni	=0.1*F36
48					
49				TOTAL	=SUM(F40:F46)
50					
51				WATER VERSION	
52				Fe	=0.1*F34
53				Cr	=0.1*F35
54				Ni	=0.1*F36
55				H	=0.1*C18
56				O	=0.1*C19
57					
58				TOTAL	=SUM(F52:F56)

APPENDIX D. MONK INPUT FILES

All monk input and output files are stored in CFS directory /w80395/crit in a UNIX* compressed and tarred format file called calciner.tar. An input filename is constructed from the case name followed by a ".inp" extension. An output filename is constructed from a case name followed by a ".prt" extension. Included in this section are printouts of the more important input files (undert3, wmp2, int55dv5, waste).

*UNIX is a trademark licensed exclusively through X\Open Company Ltd. KN

undert3.inp

```
*
* File Name       :undert3.inp
* Description     :PFP Production Calciner Glovebox
* Author          :Karl Hillesland
* Date            :April 9, 1997
*
* CSER 97-004
*
* Code           :Monk 6B
*****************************
* Product reciever vessel from calciner on floor
* Insulation soaked with water
* Hand around the three product vessels under the calciner
* Second unit is under the feed pump tank
* Calcine is 6 g Pu/cc
*****************************
*
FISSION
*****************************************************
*        MATERIAL DATA AND MAIN CONTROL DATA          *
*****************************************************
* Material #      Material Name               Symbol *
*     1           Water Mud                     P    *
*     2           Pu nitrate                    N    *
*     3           Pu solids                     S    *
*     4           Water                         W    *
*     5           304L                          4    *
*     6           310S                          0    *
*     7           Lower Insulation              L    *
*     8           Upper Insulation              U    *
*     9           SiC Filter                    F    *
*    10           Solution Mud                  M    *
*    11           Solution without nitrate      X    *
*****************************************************
* Number of Materials          Number of Nuclides
        11                           12
NUCNAMES
*
* Material 1 - Dry PuO2
WGT  6.802839  PU239 5.58  PU240 0.3  PU241 0.12 O 0.802839
*
* Material 2 - 140 g Pu/L Nitrate solution
WGT  1.234531  PU239 0.1302  PU240 0.0070  PU241 0.0028  N 0.0328
                O 0.955507  HINH2O 0.106225
*
* Material 3 - Pu solids
WGT  4.350878  PU239 1.86  PU240 0.1  PU241 0.04  N 0.468566
                O 1.850977  HINH2O 0.030906
*
* Material 4 - Water
ATOM  1.00       HINH2O  2.0   O  1.0
*
* Material 5 - 304L Stainless from ARH-600
CONC   FE 0.06331  CR 0.01654  NI 0.00651
*
* Material 6 - 310 Stainless Steel from Gieger input
CONC    C 0.001003  CR 0.022237  NI 0.015591  FE 0.048955
*
* Material 7 - Lower Calciner insulation, wet, based on Geiger
CONC    HINH2O 0.060168  O 0.036967  SI 0.000109  AL27 0.004443
*
* Material 8 - Upper Calciner insulation
* (10% density 304L Stainless from ARH-600)
* (10% water density)
WGT  0.89337  FE 0.587113  CR 0.142809  NI 0.06348
              HINH2O 0.011189  O 0.088811
*
* Material 9 - Filter material taken from Geiger
CONC  C 0.047641  SI 0.047641
*
* Material 10 - Solution mud, 450 g/L added to PuO2, without nitrate
WGT  7.382845  PU239 5.750072  PU240 0.309144  PU241 0.123657
              O 1.155535  HINH2O 0.044437
*
* Material 11 - Feed solution without nitrate, 450 g/L
```

```
WGT  1.427235  PU239 0.4185  PU240 0.0225  PU241 0.009
               O 0.867888  HINH2O 0.109347
*
INCHES
*
*************************
* Part 1 - Global
*************************
NEST 2
*      ORIGIN      x      y      z  MAT         param1 param2 param3
1  BOX                              P2          104.25 41.25  70.875
2  BOX ORIGIN    -12    -12    -12    4         128.25 65.25  94.875
*
*************************
* Part 2 - Glovebox internal
*************************
CLUSTER  12
*      ORIGIN      x      y      z  MAT      param1 param2 param3
* Calciner area - from floor of glovebox to top of calciner
*                 is 47.75 in. - .375" = 47.375"
1 ZROD ORIGIN     20 20.625  0.375   P5          20 47.375
* Feed Pump Tank
2 ZROD ORIGIN 61.125  33.25  6.375   P3       5.625     25
* Feed Reciept Tank
3 ZROD ORIGIN  88.5   33.25     34   P3        5.625    25
* Mess on Floor
4 BOX                                 1      104.25  41.25 0.375
* Scrubber Tank
5 ZROD ORIGIN  56.25      8   13.5   P4       5.625     49
* Product Receipt Vessel of second unit
6 ZROD ORIGIN 61.125  33.25  0.375    1       1.75       6
  OVERLAP 3  9 10 11   4
* Product Receipt Vessel of second unit
7 ZROD ORIGIN 58.8381 30.6004 0.375   1       1.75       6
  OVERLAP 3  9 10 11   5
* Product Receipt Vessel of second unit
8 ZROD ORIGIN 62.2762 29.9447 0.375   1       1.75       6
  OVERLAP 2  9 11   6
* Hand around first vessel of second unit
9 ZROD ORIGIN 61.125  33.25  0.375    4       2.75       6
  OVERLAP 5  6 7 8 10 11  1
* Hand around second vessel of second unit
10 ZROD ORIGIN 58.8381 30.6004 0.375  4       2.75       6
  OVERLAP 4  6 7 9 11  2
* Hand around third vessel of second unit
11 ZROD ORIGIN 62.2762 29.9447 0.375  4       2.75       6
  OVERLAP 5  6 7 8 9 10  3
* Glovebox interior
12 BOX                                 0      104.25  41.25 70.875
*
*************************
* Part 3 - Feed Pump Tank
*************************
NEST 4
*      ORIGIN      x      y      z  MAT      param1 param2 param3
* Pu solids
1 ZROD ORIGIN      0      0    0.5    3       3.094     10
* Solution - 140 g Pu/L
2 ZROD ORIGIN      0      0    0.5    2       3.094     24
* Air
3 ZROD ORIGIN      0      0    0.5    0       5.625     24
* Flanges
4 ZROD                                5       5.625     25
*
*************************
* Part 4 - Scrubber Tank
*************************
NEST 4
*      ORIGIN      x      y      z  MAT      param1 param2 param3
* Pu solids
1 ZROD ORIGIN      0      0    0.5    3       3.094     10
* Solution - 140 g Pu/L
2 ZROD ORIGIN      0      0    0.5    2       3.094     48
* Air
3 ZROD ORIGIN      0      0    0.5    0       5.625     48
* Flanges
4 ZROD                                5       5.625     49
*
```

```
**************************
* Part 5 - Calciner
**************************
CLUSTER 4
*       ORIGIN      x      y      z  MAT      param1 param2 param3
* Containers - from .375 layer to bottom of calciner = 23.875
1 ZROD ORIGIN      0      0      0   P6          20 23.875
* Lower Calciner
2 ZROD ORIGIN      0      0 23.875   P7          20    9.5
* Upper Calciner
3 ZROD ORIGIN      0      0 33.375   P8          20     14
* Total extent
4 ZROD                               0           20 47.375
*
**************************
* Part 6 - Container area
**************************
CLUSTER 7
*       ORIGIN      x      y      z  MAT      param1 param2 param3
* Product Receipt Vessel of first unit
1 ZROD ORIGIN      0      0      0   1      1.75       6
  OVERLAP 3  4 5 6  4
* Product Receipt Vessel of first unit
2 ZROD ORIGIN 1.1512 3.3053      0   1      1.75       6
  OVERLAP 3  4 5 6  5
* Product Receipt Vessel of first unit
3 ZROD ORIGIN -2.2869 2.6496     0   1      1.75       6
  OVERLAP 3  4 5 6  6
* Hand around first vessel of first unit
4 ZROD ORIGIN      0      0      0   4      2.75       6
  OVERLAP 5  1 2 3 5 6  1
* Hand around second vessel of first unit
5 ZROD ORIGIN 1.1512 3.3053      0   4      2.75       6
  OVERLAP 5  1 2 3 4 6  2
* Hand around third vessel of first unit
6 ZROD ORIGIN -2.2869 2.6496     0   4      2.75       6
  OVERLAP 5  1 2 3 4 5  3
* Container area
7 ZROD                               0         20  23.875
*
**************************
* Part 7 - Lower Calciner (External)
**************************
NEST 4
*       ORIGIN      x      y      z  MAT      param1 param2 param3
* Internal of lower calciner
1 ZROD ORIGIN      0      0    0.5   P9     3.1785    9.0
* Calciner 6" pipe
2 ZROD                               6      3.3125    9.5
* Insulation
3 ZROD ORIGIN      0      0      0   7       15.75    9.5
* Outside air
4 ZROD                               0          20    9.5
*
**************************
* Part 8 - Upper portion of Calciner (External)
**************************
NEST 4
*       ORIGIN      x      y      z  MAT      param1 param2 param3
* Internal of upper calciner
1 ZROD                              P12     3.1785     12
* Calciner 6" pipe
2 ZROD                               6      3.3125     14
* Insulation
3 ZROD ORIGIN      0      0      0   8      6.3125     14
* Air space above lower insulation
4 ZROD                               0          20     14
*
**************************
* Part 9 - Lower portion of calciner (internal)
**************************
CLUSTER 3
*       ORIGIN      x      y      z  MAT      param1 param2 param3
* Below dome
1 ZROD                              P10     3.1785   6.19
* Dome area
2 ZROD ORIGIN      0      0   6.19  P11     3.1785   2.81
* Internal of lower calciner
```

```
3 ZROD                            0      3.1785      9
*
***************************
* Part 10 - Below dome within lower portion of calciner(Internal)
***************************
NEST  3
*      ORIGIN      x      y      z  MAT      param1 param2 param3
* Calciner internal space of pipe
1 ZROD ORIGIN      0      0      0   0        2.13   6.19
* Calciner 4" pipe
2 ZROD ORIGIN      0      0      0   6        2.25   6.19
* Calcine
3 ZROD ORIGIN      0      0      0   1      3.1785   6.19
*
***************************
* Part 11 - Dome portion in calciner (Internal)
***************************
CLUSTER  4
*      ORIGIN      x      y      z  MAT      param1 param2 param3
* Inner dome
1 SPHERE ORIGIN    0      0 -2.624   0      3.4587
      OVERLAP  2  2 4   5
* Outer of dome
2 SPHERE ORIGIN    0      0 -2.624   6      3.5
      OVERLAP  2  1 4   4
* Agitator Shaft, starts 1" above top of dome
3 ZROD ORIGIN      0      0  1.8347   6        0.5  0.9753
* Empty space
4 ZROD ORIGIN      0      0      0   0      3.1785   2.81
      OVERLAP  2  1 2  6
*
***************************
* Part 12 - Upper portion of Calciner (Internal)
***************************
CLUSTER 9
*      ORIGIN      x      y      z  MAT      param1 param2 param3
* Filter 1
1 ZROD ORIGIN  1.839      0      0   9           1     12
  OVERLAP  2  4 5  2
* Filter 2
2 ZROD ORIGIN -1.839      0      0   9           1     12
  OVERLAP  2  4 6  3
* Filter 3
3 ZROD ORIGIN      0  1.839      0   9           1     12
  OVERLAP  2  4 7  4
* Steel Around tops of filters
4 ZROD ORIGIN      0      0     11   6      3.1785      1
  OVERLAP  6  1 2 3 5 6 7  1
* Solution in filter 1
5 ZROD ORIGIN  1.839      0    1.5   0       0.565   10.5
  OVERLAP 2  1 4  5
* Solution in filter 2
6 ZROD ORIGIN -1.839      0    1.5   0       0.565   10.5
  OVERLAP 2  2 4  6
* Solution in filter 3
7 ZROD ORIGIN      0  1.839    1.5   0       0.565   10.5
  OVERLAP 2  3 4  7
* Agitator shaft
8 ZROD                               6         0.5     11
* Internal of upper calciner  (container)
9 ZROD ORIGIN      0      0      0   0      3.1785     12
*
*******************
* UNIT 4
*******************
*
* Superhistory option using 10 generation per superhistory
* and nu multiplication factor = 1.0
SUPERHIST  10  1.0
* First stage  Last stage  N per stage  time  Std dev.   Source
     -2          100         500          240   STDV .003     -1
*
* Starting source
MULTIFISS
STD
REGION 2 IN PART 2 /
REGION 3 IN PART 2 /
REGION 4 IN PART 2 /
```

```
REGION 5 IN PART 2 /
REGION 6 IN PART 2 /
REGION 7 IN PART 2 /
REGION 8 IN PART 2 /
REGION 1 IN PART 6 /
REGION 2 IN PART 6 /
REGION 3 IN PART 6 /
REGION 3 IN PART 10 /
END
CODE 11
PNSW40LUFMX
*  Top left corner      Top right corner    Bottom left corner
*  x      y      z      x      y      z      x      y      z
*  x-z through feed tanks
 -12 33.25  82.875 116.25 33.25 82.875  -12  33.25  -12
*  down center of calciner
   0 20.625    48      40 20.625  48       0 20.625    0
*  close-up on dome
  15 20.625  33.75     25 20.625 33.75   15 20.625 24.25
*  x-z through scrubber
 -12     8  82.875 116.25    8  82.875  -12     8   -12
*  x-y for cans
   0 41.25     0.5    70 41.25   0.5      0     0   0.5
*  x-y for cans
  10    30     0.5    30    30   0.5     10    10   0.5
END
```

wmp2.inp

```
*
* File Name        :wmp2.inp
* Description      :PFP Production Calciner Glovebox
* Author           :Karl Hillesland
* Date             :April 25, 1997
*
* CSER 97-004
*
* Code           :Monk 6B
****************************
* Product reciever vessel from calciner on floor
* Second unit is under the feed pump tank
* Calcine is 5.5 g Pu/cc
* External water spill
* 10" solids
* Two cans in each unit
*   Entire glovebox interior covered in 0.2 g/cc water mist
****************************
*
FISSION
*****************************************************
*        MATERIAL DATA AND MAIN CONTROL DATA        *
*****************************************************
* Material #      Material Name               Symbol *
*     1           Water Mud                     P    *
*     2           Pu nitrate                    N    *
*     3           Pu solids                     S    *
*     4           Water                         W    *
*     5           304L                          4    *
*     6           310S                          0    *
*     7           Lower Insulation              L    *
*     8           Upper Insulation              U    *
*     9           SiC Filter                    F    *
*    10           Solution Mud                  M    *
*    11           Solution without nitrate      X    *
*    12           Mist                          A    *
*****************************************************
* Number of Materials           Number of Nuclides
        12                           12
NUCNAMES
*
* Material 1 - Dry PuO2
WGT  6.235936  PU239 5.225  PU240 0.275  PU241 0.11 O 0.735936
*
* Material 2 - 140 g Pu/L Nitrate solution
WGT  1.234531  PU239 0.1302  PU240 0.0070  PU241 0.0028  N 0.0328
                O 0.955507  HINH2O 0.106225
*
* Material 3 - Pu solids
WGT  4.350878  PU239 1.86  PU240 0.1  PU241 0.04  N 0.468566
                O 1.850977  HINH2O 0.030906
*
* Material 4 - Water
ATOM  1.00       HINH2O  2.0   O  1.0
*
* Material 5 - 304L Stainless from ARH-600
CONC   FE 0.06331  CR 0.01654  NI 0.00651
*
* Material 6 - 310 Stainless Steel from Gieger input
CONC    C 0.001003  CR 0.022237  NI 0.015591  FE 0.048955
*
* Material 7 - Lower Calciner insulation, dry, based on Geiger
CONC    O 0.006883  SI 0.000109  AL27 0.004443
*
* Material 8 - Upper Calciner insulation
* (10% density 304L Stainless from ARH-600)
CONC           FE 0.006331  CR 0.001654  NI 0.000651
*
* Material 9 - Filter material taken from Geiger
CONC  C 0.047641  SI 0.047641
*
* Material 10 - Solution mud, 450 g/L added to PuO2, without nitrate
*               Calcine is 5.5 g Pu/cc
WGT  6.886544  PU239 5.305774  PU240 0.285257  PU241 0.114103
               O 1.131564  HINH2O 0.049846
```

```
*
* Material 11 - Feed solution without nitrate, 450 g/L
WGT  1.427235  PU239 0.4185  PU240 0.0225  PU241 0.009
               O 0.867888  HINH2O 0.109347
*
* Material 12 - Water mist
ATOM  0.2     HINH2O 2.0  O 1.0
*
INCHES
*
*************************
* Part 1 - Global
************************
NEST 2
*      ORIGIN      x      y      z  MAT         param1 param2 param3
1  BOX                              P2          104.25 41.25  70.875
2  BOX ORIGIN    -12    -12    -12   4          128.25 65.25  94.875
*
************************
* Part 2 - Glovebox internal
************************
CLUSTER  8
*      ORIGIN      x      y      z  MAT      param1 param2 param3
* Calciner area - from floor of glovebox to top of calciner
*                 is 47.75 in. - .375" = 47.375"
1 ZROD ORIGIN     20 20.625  0.375   P5          20 47.375
* Feed Pump Tank
2 ZROD ORIGIN 61.125  33.25  6.375   P3       5.625     25
* Feed Reciept Tank
3 ZROD ORIGIN  88.5   33.25     34   P3        5.625    25
* Mess on Floor
4 BOX                               10      104.25  41.25 0.375
* Scrubber Tank
5 ZROD ORIGIN  56.25      8   13.5   P4       5.625     49
* Product Receipt Vessel of second unit
6 ZROD ORIGIN 61.125  33.25  0.375  10       1.75       6
* Product Receipt Vessel of second unit
7 ZROD ORIGIN 58.8381 30.6004 0.375  10       1.75       6
* Glovebox interior
8  BOX                              12       104.25  41.25 70.875
*
*************************
* Part 3 - Feed Pump Tank
*************************
NEST 4
*      ORIGIN      x      y      z  MAT      param1 param2 param3
* Pu solids
1 ZROD ORIGIN      0      0    0.5    3       3.094     10
* Solution - 140 g Pu/L
2 ZROD ORIGIN      0      0    0.5    2       3.094     24
* Air
3 ZROD ORIGIN      0      0    0.5   12       5.625     24
* Flanges
4 ZROD                                5       5.625     25
*
*************************
* Part 4 - Scrubber Tank
*************************
NEST 4
*      ORIGIN      x      y      z  MAT      param1 param2 param3
* Pu solids
1 ZROD ORIGIN      0      0    0.5    3       3.094     10
* Solution - 140 g Pu/L
2 ZROD ORIGIN      0      0    0.5    2       3.094     48
* Air
3 ZROD ORIGIN      0      0    0.5   12       5.625     48
* Flanges
4 ZROD                                5       5.625     49
*
**************************
* Part 5 - Calciner
**************************
CLUSTER 4
*      ORIGIN      x      y      z  MAT      param1 param2 param3
* Containers - from .375 layer to bottom of calciner = 23.875
1 ZROD ORIGIN      0      0      0   P6          20 23.875
* Lower Calciner
2 ZROD ORIGIN      0      0 23.875   P7          20    9.5
```

```
* Upper Calciner
3 ZROD ORIGIN       0       0 33.375   P8          20      14
* Total extent
4 ZROD                                  0          20 47.375
*
**************************
* Part 6 - Container area
**************************
CLUSTER 3
*       ORIGIN       x       y       z  MAT       param1 param2 param3
* Product Receipt Vessel of first unit
1 ZROD ORIGIN       0       0       0  10        1.75       6
* Product Receipt Vessel of first unit
2 ZROD ORIGIN 1.1512 3.3053       0  10        1.75       6
* Container area
3 ZROD                                 12          20  23.875
*
**************************
* Part 7 - Lower Calciner (External)
**************************
NEST 4
*       ORIGIN       x       y       z  MAT       param1 param2 param3
* Internal of lower calciner
1 ZROD ORIGIN       0       0     0.5   P9      3.1785     9.0
* Calciner 6" pipe
2 ZROD                                  6      3.3125     9.5
* Insulation
3 ZROD ORIGIN       0       0       0   7       15.75     9.5
* Outside air
4 ZROD                                 12          20     9.5
*
**************************
* Part 8 - Upper portion of Calciner (External)
**************************
NEST 4
*       ORIGIN       x       y       z  MAT       param1 param2 param3
* Internal of upper calciner
1 ZROD                                P12      3.1785      12
* Calciner 6" pipe
2 ZROD                                  6      3.3125      14
* Insulation
3 ZROD ORIGIN       0       0       0   8      6.3125      14
* Air space above lower insulation
4 ZROD                                 12          20      14
*
**************************
* Part 9 - Lower portion of calciner (internal)
**************************
CLUSTER 3
*       ORIGIN       x       y       z  MAT       param1 param2 param3
* Below dome
1 ZROD                                P10      3.1785    6.19
* Dome area
2 ZROD ORIGIN       0       0    6.19  P11      3.1785    2.81
* Internal of lower calciner
3 ZROD                                  0      3.1785       9
*
**************************
* Part 10 - Below dome within lower portion of calciner(Internal)
**************************
NEST  3
*       ORIGIN       x       y       z  MAT       param1 param2 param3
* Calciner internal space of pipe
1 ZROD ORIGIN       0       0       0  12        2.13    6.19
* Calciner 4" pipe
2 ZROD ORIGIN       0       0       0   6        2.25    6.19
* Calcine
3 ZROD ORIGIN       0       0       0   1      3.1785    6.19
*
**************************
* Part 11 - Dome portion in calciner (Internal)
**************************
CLUSTER  4
*       ORIGIN       x       y       z  MAT       param1 param2 param3
* Inner dome
1 SPHERE ORIGIN     0       0 -2.624   12     3.4587
       OVERLAP  2   2 4    5
* Outer of dome
```

```
2 SPHERE ORIGIN    0      0 -2.624    6      3.5
      OVERLAP  2  1 4   4
* Agitator Shaft, starts 1" above top of dome
3 ZROD ORIGIN      0      0  1.8347   6        0.5  0.9753
* Empty space filled with wet calcine
4 ZROD ORIGIN      0      0      0    1      3.1785   2.81
      OVERLAP  2  1 2  6
*
**************************
* Part 12 - Upper portion of Calciner (Internal)
**************************
CLUSTER 9
*      ORIGIN      x      y      z  MAT      param1 param2 param3
* Filter 1
1 ZROD ORIGIN  1.839      0      0    9          1     12
  OVERLAP  2  4 5  2
* Filter 2
2 ZROD ORIGIN -1.839      0      0    9          1     12
  OVERLAP  2  4 6  3
* Filter 3
3 ZROD ORIGIN      0  1.839      0    9          1     12
  OVERLAP  2  4 7  4
* Steel Around tops of filters
4 ZROD ORIGIN      0      0     11    6      3.1785      1
  OVERLAP  6  1 2 3 5 6 7  1
* Solution in filter 1
5 ZROD ORIGIN  1.839      0    1.5    0       0.565   10.5
  OVERLAP 2  1 4  5
* Solution in filter 2
6 ZROD ORIGIN -1.839      0    1.5    0       0.565   10.5
  OVERLAP 2  2 4  6
* Solution in filter 3
7 ZROD ORIGIN      0  1.839    1.5    0       0.565   10.5
  OVERLAP 2  3 4  7
* Agitator shaft
8 ZROD                                6         0.5     11
* Internal of upper calciner  (container)
9 ZROD ORIGIN      0      0      0    1      3.1785     12
*
******************
* UNIT 4
******************
*
* Superhistory option using 10 generation per superhistory
* and nu multiplication factor = 1.0
SUPERHIST  10  1.0
* First stage  Last stage  N per stage  time  Std dev.   Source
     -3          100        500          240   STDV .003     -1
*
* Starting source
MULTIFISS
STD
REGION 2 IN PART 2 /
REGION 3 IN PART 2 /
REGION 4 IN PART 2 /
REGION 5 IN PART 2 /
REGION 6 IN PART 2 /
REGION 7 IN PART 2 /
REGION 1 IN PART 6 /
REGION 2 IN PART 6 /
REGION 3 IN PART 10 /
REGION 4 IN PART 11 /
REGION 9 IN PART 12 /
END
CODE 12
PNSW40LUFMXA
*  Top left corner     Top right corner   Bottom left corner
*  x      y      z      x     y     z      x     y     z
*  x-z through feed tanks
 -12 33.25   82.875 116.25 33.25 82.875  -12  33.25  -12
*  down center of calciner
   0 20.625    48      40 20.625  48      0 20.625    0
*  close-up on dome
  15 20.625  33.75     25 20.625 33.75   15 20.625 24.25
*  x-z through scrubber
 -12      8  82.875 116.25     8  82.875  -12     8   -12
*  x-y for cans
   0 41.25     0.5    70 41.25   0.5      0     0   0.5
```

```
*  x-y for cans
  10    30     0.5    30    30   0.5     10    10   0.5
END
```

int55dv5.inp

```
*
* File Name         :int55dv5.inp
* Description       :PFP Production Calciner Glovebox
* Author            :Karl Hillesland
* Date              :April 30, 1997
*
* CSER 97-004
*
* Code             :Monk 6B
****************************
* Product reciever vessels on floor
* Insulation soaked with water
* Hand around the product vessels
* Second unit is under the feed pump tank
* Calcine is 5.5 g Pu/cc
* Mud inside calciner, nitrate included
* 20" solids
* Two cans in each unit
****************************
*
FISSION
*****************************************************
*        MATERIAL DATA AND MAIN CONTROL DATA        *
*****************************************************
* Material #      Material Name              Symbol *
*     1           Water Mud                    P    *
*     2           Pu nitrate                   N    *
*     3           Pu solids                    S    *
*     4           Water                        W    *
*     5           304L                         4    *
*     6           310S                         0    *
*     7           Lower Insulation             L    *
*     8           Upper Insulation             U    *
*     9           SiC Filter                   F    *
*    10           Solution Mud                 M    *
*    11           Solution without nitrate     X    *
*****************************************************
* Number of Materials          Number of Nuclides
        11                          12
NUCNAMES
*
* Material 1 - Dry PuO2
WGT  6.235936  PU239 5.115  PU240 0.275  PU241 0.11 O 0.735936
*
* Material 2 - 140 g Pu/L Nitrate solution
WGT  1.234531  PU239 0.1302  PU240 0.0070  PU241 0.0028  N 0.0328
               O 0.955507  HINH2O 0.106225
*
* Material 3 - Pu solids
WGT  4.350878  PU239 1.86  PU240 0.1  PU241 0.04  N 0.468566
               O 1.850977  HINH2O 0.030906
*
* Material 4 - Water
ATOM  1.00       HINH2O  2.0   O  1.0
*
* Material 5 - 304L Stainless from ARH-600
CONC   FE 0.06331  CR 0.01654  NI 0.00651
*
* Material 6 - 310 Stainless Steel from Gieger input
CONC     C 0.001003  CR 0.022237  NI 0.015591  FE 0.048955
*
* Material 7 - Lower Calciner insulation, wet, based on Geiger
CONC     HINH2O 0.060168  O 0.036967  SI 0.000109  AL27 0.004443
*
* Material 8 - Upper Calciner insulation
* (10% density 304L Stainless from ARH-600)
* (10% water density)
WGT  0.89337  FE 0.587113  CR 0.142809  NI 0.06348
              HINH2O 0.011189  O 0.088811
*
* Material 9 - Filter material taken from Geiger
CONC  C 0.047641  SI 0.047641
*
* Material 10 - Solution mud, 450 g/L added to PuO2, with nitrate
*                Calcine is 5.5 g Pu/cc
```

```
WGT  7.035432  PU239 5.305774  PU240 0.285257  PU241 0.114103
               O 1.239539  HINH2O 0.042701 N 0.048059
*
* Material 11 - Feed solution without nitrate, 450 g/L
WGT  1.427235  PU239 0.4185  PU240 0.0225  PU241 0.009
               O 0.867888  HINH2O 0.109347
*
INCHES
*
**************************
* Part 1 - Global
*************************
NEST 2
*      ORIGIN      x      y      z  MAT         param1 param2 param3
1  BOX                               P2          104.25 41.25  70.875
2  BOX ORIGIN    -12    -12    -12    4          128.25 65.25  94.875
*
*************************
* Part 2 - Glovebox internal
*************************
CLUSTER  10
*      ORIGIN      x      y      z  MAT      param1 param2 param3
* Calciner area - from floor of glovebox to top of calciner
*                is 47.75 in. - .375" = 47.375"
1 ZROD ORIGIN     20 20.625  0.375   P5          20 47.375
* Feed Pump Tank
2 ZROD ORIGIN 61.125  33.25  6.375   P3       5.625     25
* Feed Reciept Tank
3 ZROD ORIGIN  88.5   33.25     34   P3        5.625    25
* Mess on Floor
4 BOX                                 1      104.25   41.25 0.375
* Scrubber Tank
5 ZROD ORIGIN  56.25      8   13.5   P4       5.625     49
* Product Receipt Vessel of second unit
6 ZROD ORIGIN 61.125  33.25  0.375    1       1.75       6
  OVERLAP 2  8 9   7
* Product Receipt Vessel of second unit
7 ZROD ORIGIN 58.8381 30.6004 0.375   1       1.75       6
  OVERLAP 2  8 9   6
* Hand around first vessel of second unit
8 ZROD ORIGIN 61.125  33.25  0.375    4       2.75       6
  OVERLAP 3  6 7 9   3
* Hand around second vessel of second unit
9  ZROD ORIGIN 58.8381 30.6004 0.375  4       2.75       6
  OVERLAP 3  6 7 8   4
* Glovebox interior
10 BOX                                 0      104.25  41.25 70.875
*
*************************
* Part 3 - Feed Pump Tank
*************************
NEST 4
*      ORIGIN      x      y      z  MAT      param1 param2 param3
* Pu solids
1 ZROD ORIGIN      0      0    0.5    3       3.094     20
* Solution - 140 g Pu/L
2 ZROD ORIGIN      0      0    0.5    2       3.094     24
* Air
3 ZROD ORIGIN      0      0    0.5    0       5.625     24
* Flanges
4 ZROD                                5       5.625     25
*
*************************
* Part 4 - Scrubber Tank
*************************
NEST 4
*      ORIGIN      x      y      z  MAT      param1 param2 param3
* Pu solids
1 ZROD ORIGIN      0      0    0.5    3       3.094     20
* Solution - 140 g Pu/L
2 ZROD ORIGIN      0      0    0.5    2       3.094     48
* Air
3 ZROD ORIGIN      0      0    0.5    0       5.625     48
* Flanges
4 ZROD                                5       5.625     49
*
**************************
* Part 5 - Calciner
```

```
***************************
CLUSTER 4
*      ORIGIN      x       y       z  MAT      param1 param2 param3
* Containers - from .375 layer to bottom of calciner = 23.875
1 ZROD ORIGIN      0       0       0   P6          20 23.875
* Lower Calciner
2 ZROD ORIGIN      0       0 23.875    P7          20    9.5
* Upper Calciner
3 ZROD ORIGIN      0       0 33.375    P8          20     14
* Total extent
4 ZROD                                 0           20 47.375
*
*
***************************
* Part 6 - Container area
***************************
CLUSTER 6
*      ORIGIN      x       y       z  MAT      param1 param2 param3
* Product Receipt Vessel
1 ZROD ORIGIN -1.5815      0       0   10        1.75      6
  OVERLAP  2  3 4  5
* Product Receipt Vessel
2 ZROD ORIGIN  1.9185      0       0    1        1.75      6
  OVERLAP  2  3 4  6
* Hand
3 ZROD ORIGIN -1.5815      0       0    4        2.75      6
  OVERLAP  3  1 2 4  1
* Hand
4 ZROD ORIGIN  1.9185      0       0    4        2.75      6
  OVERLAP  3  1 2 3  2
* Downcomer
5 ZROD ORIGIN -1.5815      0       6   10      0.4395  17.875
* Container area
6 ZROD                                  0          20  23.875
*
***************************
* Part 7 - Lower Calciner (External)
***************************
NEST 4
*      ORIGIN      x       y       z  MAT      param1 param2 param3
* Internal of lower calciner
1 ZROD ORIGIN      0       0       0   P9      3.1785    9.5
* Calciner 6" pipe
2 ZROD                                  6      3.3125    9.5
* Insulation
3 ZROD ORIGIN      0       0       0    7       15.75    9.5
* Outside air
4 ZROD                                  0          20    9.5
*
***************************
* Part 8 - Upper portion of Calciner (External)
***************************
NEST 4
*      ORIGIN      x       y       z  MAT      param1 param2 param3
* Internal of upper calciner
1 ZROD                                P12      3.1785     12
* Calciner 6" pipe
2 ZROD                                  6      3.3125     14
* Insulation
3 ZROD ORIGIN      0       0       0    8      6.3125     14
* Air space above lower insulation
4 ZROD                                  0          20     14
*
***************************
* Part 9 - Lower portion of calciner (internal)
***************************
CLUSTER 3
*      ORIGIN      x       y       z  MAT      param1 param2 param3
* Below dome
1 ZROD                                P10      3.1785  6.625
* Dome area
2 ZROD ORIGIN      0       0  6.625   P11      3.1785  2.875
* Internal of lower calciner
3 ZROD                                  0      3.1785    9.5
*
***************************
* Part 10 - Below dome within lower portion of calciner(Internal)
***************************
```

```
CLUSTER 7
*      ORIGIN      x      y      z  MAT      param1 param2 param3
* Calciner internal space of pipe
1 ZROD ORIGIN      0      0      0    0        2.13  6.625
  OVERLAP  5  2 3 4 5 6  20
* Calciner 4" pipe
2 ZROD ORIGIN      0      0    0.5    6        2.25  6.125
  OVERLAP  4  1 3 4 5  8
* Calcine in calciner
3 ZROD ORIGIN      0      0    0.5   10      3.1785  6.125
  OVERLAP  4  1 2 4 5  6
* Downcommer pipe
4 ZROD ORIGIN -1.5815     0      0   10      0.4395  4.875
  OVERLAP  5  1 2 3 5 6  30
* Slot
*        MAT      xmax   ymax  zmax   xmin    ymin  zmin
5 CUBOID  10   -1.5815 0.4395 4.875  -2.13 -0.4395   0.5
  OVERLAP  4  1 2 3 4  25
* Bottom plate
6 ZROD                                6      3.1785    0.5
  OVERLAP  2  1 4  3
* Bounding area
7 ZROD                                0      3.1785  6.625
*
**************************
* Part 11 - Dome portion in calciner (Internal)
**************************
CLUSTER  4
*      ORIGIN      x      y      z  MAT      param1 param2 param3
* Inner dome
1 SPHERE ORIGIN    0      0 -2.624    0     3.4587
       OVERLAP  2  2 4   5
* Outer of dome
2 SPHERE ORIGIN    0      0 -2.624    6      3.5
       OVERLAP  2  1 4   4
* Agitator Shaft, starts 1" above top of dome
3 ZROD ORIGIN      0      0  1.8347   6        0.5  0.9753
* Empty space
4 ZROD ORIGIN      0      0      0   10      3.1785  2.875
       OVERLAP  2  1 2  6
*
**************************
* Part 12 - Upper portion of Calciner (Internal)
**************************
CLUSTER 9
*      ORIGIN      x      y      z  MAT      param1 param2 param3
* Filter 1
1 ZROD ORIGIN  1.839      0      0    9           1     12
  OVERLAP  2  4 5  2
* Filter 2
2 ZROD ORIGIN -1.839      0      0    9           1     12
  OVERLAP  2  4 6  3
* Filter 3
3 ZROD ORIGIN      0  1.839      0    9           1     12
  OVERLAP  2  4 7  4
* Steel Around tops of filters
4 ZROD ORIGIN      0      0     11    6      3.1785      1
  OVERLAP  6  1 2 3 5 6 7  1
* Solution in filter 1
5 ZROD ORIGIN  1.839      0  1.125   11     0.71875 10.875
  OVERLAP 2  1 4  5
* Solution in filter 2
6 ZROD ORIGIN -1.839      0  1.125   11     0.71875 10.875
  OVERLAP 2  2 4  6
* Solution in filter 3
7 ZROD ORIGIN      0  1.839  1.125   11     0.71875 10.875
  OVERLAP 2  3 4  7
* Agitator shaft
8 ZROD                                6         0.5     11
* Internal of upper calciner  (container)
9 ZROD ORIGIN      0      0      0   10      3.1785     12
*
******************
* UNIT 4
******************
*
* Superhistory option using 10 generation per superhistory
* and nu multiplication factor = 1.0
```

```
SUPERHIST  10  1.0
* First stage  Last stage  N per stage  time  Std dev.   Source
     -3          100         500          240   STDV .003     -1
*
* Starting source
MULTIFISS
STD
REGION 2 IN PART 2 /
REGION 3 IN PART 2 /
REGION 4 IN PART 2 /
REGION 5 IN PART 2 /
REGION 6 IN PART 2 /
REGION 7 IN PART 2 /
REGION 1 IN PART 6 /
REGION 2 IN PART 6 /
REGION 3 IN PART 10 /
REGION 4 IN PART 11 /
REGION 5 IN PART 12 /
REGION 6 IN PART 12 /
REGION 7 IN PART 12 /
REGION 9 IN PART 12 /
END
CODE 11
PNSW40LUFMX
*  Top left corner      Top right corner    Bottom left corner
*  x     y       z      x     y     z      x     y     z
*  x-z through feed tanks
 -12 33.25  82.875 116.25 33.25 82.875  -12  33.25  -12
*  down center of calciner
   0 20.625    48      40 20.625  48      0 20.625    0
*  close-up on dome
  15 20.625  33.75     25 20.625 33.75   15 20.625 24.25
*  x-z through scrubber
 -12     8  82.875 116.25    8  82.875  -12     8   -12
*  x-y for cans
   0 41.25     0.5    70 41.25   0.5      0     0   0.5
*  x-y for cans
  10    30     0.5    30    30   0.5     10    10   0.5
END
```

waste.inp

```
*
* File Name       :waste.inp
* Description     :PFP Production Calciner Glovebox
* Author          :Karl Hillesland
* Date            :April 12, 1997
*
* CSER 97-004
*
* Code           :Monk 6B
*****************************
* Waste section of glovebox
* Calcine is 6 g Pu/cc
*****************************
*
FISSION
******************************************************
*        MATERIAL DATA AND MAIN CONTROL DATA         *
******************************************************
* Material #     Material Name               Symbol *
*     1          Water Mud                      P   *
*     2          Pu nitrate                     N   *
*     3          Pu solids                      S   *
*     4          Water                          W   *
*     5          304L                           4   *
*     6          310S                           0   *
*     7          Lower Insulation               L   *
*     8          Upper Insulation               U   *
*     9          SiC Filter                     F   *
*    10          Solution Mud                   M   *
*    11          Solution without nitrate       X   *
******************************************************
* Number of Materials          Number of Nuclides
        11                            12
NUCNAMES
*
* Material 1 - Dry PuO2
WGT  6.802839  PU239 5.58  PU240 0.3  PU241 0.12 O 0.802839
*
* Material 2 - 140 g Pu/L Nitrate solution
WGT  1.234531  PU239 0.1302  PU240 0.0070  PU241 0.0028  N 0.0328
               O 0.955507  HINH2O 0.106225
*
* Material 3 - Pu solids
WGT  4.350878  PU239 1.86  PU240 0.1  PU241 0.04  N 0.468566
               O 1.850977  HINH2O 0.030906
*
* Material 4 - Water
ATOM  1.00       HINH2O  2.0   O  1.0
*
* Material 5 - 304L Stainless from ARH-600
CONC   FE 0.06331  CR 0.01654  NI 0.00651
*
* Material 6 - 310 Stainless Steel from Gieger input
CONC    C 0.001003  CR 0.022237  NI 0.015591  FE 0.048955
*
* Material 7 - Lower Calciner insulation, wet, based on Geiger
CONC    HINH2O 0.060168  O 0.036967  SI 0.000109  AL27 0.004443
*
* Material 8 - Upper Calciner insulation
* (10% density 304L Stainless from ARH-600)
* (10% water density)
WGT  0.89337  FE 0.587113  CR 0.142809  NI 0.06348
             HINH2O 0.011189  O 0.088811
*
* Material 9 - Filter material taken from Geiger
CONC  C 0.047641  SI 0.047641
*
* Material 10 - Solution mud, 450 g/L added to PuO2, without nitrate
WGT  7.382845  PU239 5.750072  PU240 0.309144  PU241 0.123657
               O 1.155535  HINH2O 0.044437
*
* Material 11 - Feed solution without nitrate, 450 g/L
WGT  1.427235  PU239 0.4185  PU240 0.0225  PU241 0.009
               O 0.867888  HINH2O 0.109347
*
```

```
*
INCHES
*
*************************
* Part 1 - Global
*************************
NEST 2
*      ORIGIN      x      y      z  MAT         param1 param2 param3
1  BOX                              P2              42     49 70.875
2  BOX ORIGIN    -12    -12    -12   4              66     73 94.875
*
*************************
* Part 2 - Glovebox internal
*************************
CLUSTER  18
*      ORIGIN      x      y      z  MAT      param1 param2 param3
* -x -y catch tank
1 ZROD ORIGIN 7.5625   13.5  12.25   P3       5.625     49
* +x -y catch tank (x=42-7.5625)
2 ZROD ORIGIN 34.4375  13.5  12.25   P3       5.625     49
* -x +y catch tank
3 ZROD ORIGIN 7.5625   35.5  12.25   P3       5.625     49
* +x +y catch tank (x=42-7.5625)
4 ZROD ORIGIN 34.4375  35.5  12.25   P3       5.625     49
* Mess on Floor
5 BOX                                 1          42     49 0.375
* Product Receipt Vessel under +x -y
6 ZROD ORIGIN 34.4375  13.5  0.375   1       1.75       6
  OVERLAP 3  9 10 11   4
* Product Receipt Vessel under +x -y   x-1.75   y+3.0311
7 ZROD ORIGIN 32.6875 16.5311 0.375   1       1.75       6
  OVERLAP 3  9 10 11   4
* Product Receipt Vessel under +x -y   x+1.75   y+3.0311
8 ZROD ORIGIN 36.1875 16.5311 0.375   1       1.75       6
  OVERLAP 3  9 10 11   4
* Hand around first vessel of +x -y unit
9 ZROD ORIGIN 34.4375  13.5  0.375   4       2.75       6
  OVERLAP 5  6 7 8 10 11  1
* Hand around second vessel of +x -y   x-1.75   y+3.0311
10 ZROD ORIGIN 32.6875 16.5311 0.375  4       2.75       6
  OVERLAP 5  6 7 8 9 11   2
* Hand around third vessel of  +x -y   x+1.75   y+3.0311
11 ZROD ORIGIN 36.1875 16.5311 0.375  4       2.75       6
  OVERLAP 5  6 7 8 9 10   3
*
*SECOND UNIT
* Product Receipt Vessel under +x +y
12 ZROD ORIGIN 34.4375  35.5  0.375   1       1.75       6
  OVERLAP 3 15 16 17   4
* Product Receipt Vessel under +x +y   x-1.75   y-3.0311
13 ZROD ORIGIN 32.6875 32.4689 0.375  1       1.75       6
  OVERLAP 3 15 16 17   4
* Product Receipt Vessel under +x +y   x+1.75   y-3.0311
14 ZROD ORIGIN 36.1875 32.4689 0.375  1       1.75       6
  OVERLAP 3 15 16 17   4
* Hand around first vessel of +x +y unit
15 ZROD ORIGIN 34.4375  35.5  0.375   4       2.75       6
  OVERLAP 5  12 13 14 16 17  1
* Hand around second vessel of +x +y   x-1.75   y-3.0311
16 ZROD ORIGIN 32.6875 32.4689 0.375  4       2.75       6
  OVERLAP 5  12 13 14 15 17  2
* Hand around third vessel of  +x +y   x+1.75   y-3.0311
17 ZROD ORIGIN 36.1875 32.4689 0.375  4       2.75       6
  OVERLAP 5  12 13 14 15 16  3
* Glovebox interior
18 BOX                                 0          42    49  70.875
*
*************************
* Part 2 - Scrubber Tank
*************************
NEST 4
*      ORIGIN      x      y      z  MAT      param1 param2 param3
* Pu solids
1 ZROD ORIGIN      0      0    0.5    3       3.094     10
* Solution - 140 g Pu/L
2 ZROD ORIGIN      0      0    0.5    2       3.094     48
* Air
3 ZROD ORIGIN      0      0    0.5    0       5.625     48
```

```
* Flanges
4 ZROD                              5       5.625     49
*
******************
* UNIT 4
******************
*
* Superhistory option using 10 generation per superhistory
* and nu multiplication factor = 1.0
SUPERHIST  10  1.0
* First stage  Last stage  N per stage  time  Std dev.   Source
     -2          100        500           240   STDV .003     -1
*
* Starting source
MULTIFISS
STD
REGION 1 IN PART 2 /
REGION 2 IN PART 2 /
REGION 3 IN PART 2 /
REGION 4 IN PART 2 /
REGION 5 IN PART 2 /
REGION 6 IN PART 2 /
REGION 7 IN PART 2 /
REGION 8 IN PART 2 /
REGION 12 IN PART 2 /
REGION 13 IN PART 2 /
REGION 14 IN PART 2 /
END
CODE 11
PNSW40LUFMX
*  Top left corner     Top right corner   Bottom left corner
*  x      y      z      x      y      z      x      y      z
*  x-y through tanks
 -12    61     24     54     61     24     -12    -12    24
*  x-z through +x tanks
34.4375 -12 82.875 34.4375  61 82.875 34.4375 -12   -12
*  x-y through cans
 -12    61      1     54     61      1     -12    -12     1
END
```

ATTACHMENT 1. CORRESPONDENCE CONCERNING FEED SOLUTION CONCENTRATION

This message is a reply to a previous message. The reply is given in italics in the body of the message.

Author: Gregory G Bergquist at ~HANFORD03B
Date: 3/6/97 3:40 PM
Priority: Normal
CC: Edward M Miller at ~HANFORD02D
CC: Laurren T (Tom) Nirider
TO: Karl E Hillesland at ~HANFORD07A
Subject: Re: Solution Pu concentration and drawings
------------------------------ Message Contents ------------------------------

Greg,

In the CSER for the lab calciner, the maximum Pu concentration was 450 g Pu/L of feed solution. Is this still the greatest credible concentration?

Yes, The PUREX and PRF processes had crit limits that required nitrate solutions to be less than 450 g/l (see CPS-Z-165-80701). If they were found higher, they were immediately diluted. The highest projected concentration of nitrate in PR Can storage is about 420 g/l based on one PR Can having a Pu value of 3365 grams in 8.0-8.5 liters of solution.

Additionally, glovebox HC-227S will have a limit of 450 g/l for solution transferred from PR cans into the glass batch tanks and will be verified by sample prior to sending to the new calciner glovebox. Each PR can unload is accompanied by a 2-3 liter flush with dilute nitric acid thus providing additional dilution.

... [Remainder of message not included]

ATTACHMENT 2. CORRESPONDENCE CONCERNING PRODUCT DENSITY PRODUCED BY THE LAB CALCINER

The original was written by J.A. Compton, and forwarded by L.T. Nirider

Author: Laurren T (Tom) Nirider at ~HANFORD03B
Date: 3/18/97 8:50 AM
Priority: Normal
TO: Karl E Hillesland at ~HANFORD07A
Subject: Vertical Calciner Product Tap Densities
------------------------------ Message Contents ------------------------------

I have reviewed the lab notebook and lab analysis results regarding our product samples from the vertical calciner for runs to date. It would be stretching things a bit to say we're definitely at an asymptote on the tap density of plutonium in the product. I am attaching the Lotus 1-2-3 files with my tables and graph to show the Pu tap densities over time. The last entry for Pu tap density is clearly higher than what had started to look a bit like an asymptote, so I can't really say we've peaked. Nonetheless, I still don't think we're going to exceed 5 gm Pu per cc by much, if at all. Our latest result of 4.75 gm Pu/cc was, no doubt, assisted by having been reroasted powder from an earlier run whose product had a high loss on ignition. The highest Pu tap density without reroasting is only 4.26.

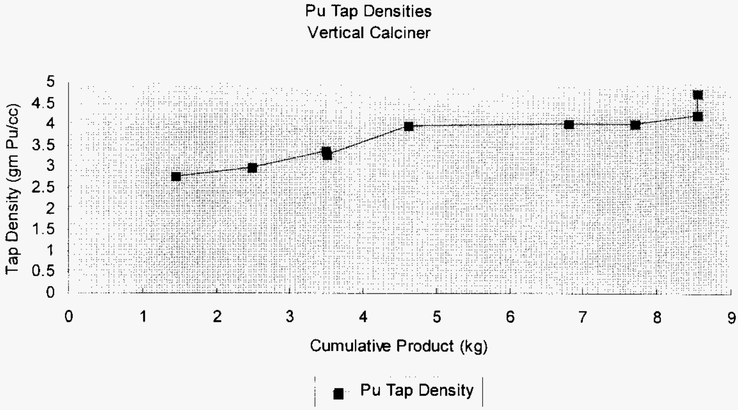
One other point needs to be made and is not shown in the 1-2-3 table attached. We started with a pretty impure PuO_2 bed and have increased the Pu fraction in the bed significantly. In other words, the Pu fraction and, therefore, the Pu density started low partly because the bed was fairly loaded with impurities. As we fed more and more reasonably pure PUREX and PRF solutions through the calciner, the Pu fraction in the bed increased. That fraction started around 0.75 and is now up to 0.855 as of the last sample results. The theoretical maximum Pu fraction is 0.882, so we won't be getting much higher. As we reach our asymptote on the Pu fraction, that factor will stop assisting the increase in Pu tap density. Please remember that the production calciner will have occasional batches of impure feeds that will lower its product Pu fraction and Pu tap density.

We clearly need to continue running the calciner to see where the Pu tap density stops, among other reasons. We plan to do so as soon as the administrative hold on fissile material handling is lifted. I still don't believe we'll exceed 5.0 gm Pu/cc consistently and I'm even more certain we won't reach 5.5 gm Pu/cc.

Pu Tap Density Tracking

gm Pu/cc (not gm PuO2/cc)

Run #	Cumulative Prod. (kg)	Pu Tap Dens(gm/cc)
=====	=====	=====
Pu-7	1.45	2.77
PP-01	2.48	2.97
PP-01	3.48	3.37
PP-02	3.5	3.27
PP-03	4.62	3.98
PP-05	6.8	4.04
PP-06	7.69	4.04
PP-07	8.54	4.26
Post	8.54	4.75


Pu Tap Densities
Vertical Calciner
Tap Density (gm Pu/cc)
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0
1
2
3
4
5
6
7
8
9
Cumulative Product (kg)
Pu Tap Density

ATTACHMENT 3. PR CANS CONTAINING URANIUM TO BE CALCINED

Post-it® Fax Note 7671	Date 3/7/97	# of pages ▶ 3
To Karl Hillesland	From Bergquist	
Co./Dept.	Co.	
Phone #	Phone #	
Fax #	Fax #	

Uranium

→ PR can ~ 8.5 liters, 10L ~ 10 liters

Solutions Containing Uranium												
Item ID	**Pu (g)**	**%Pu240**	**Type Can**	**Can #**	**Material Ty**	**Est. Sep Da**	**ANSI**	**Cat Code**	**U - g**	**Type**	**U235**	
81-88-09-235	1786	22.7	PR	E519	PU-DEP U	1988	F40	81	49	Depleted	0.70%	
81-88-09-236	1780	22.7	PR	E349	PU-DEP U	1988	F40	81	49	Depleted	0.70%	
81-88-09-237	1782	22.7	PR	E364	PU-DEP U	1988	F40	81	49	Depleted	0.70%	
81-88-09-238	1790	22.7	PR	E439	PU-DEP U	1988	F40	81	49	Depleted	0.70%	
81-88-09-239	1782	22.7	PR	E307	PU-DEP U	1988	F40	81	49	Depleted	0.70%	
81-88-09-240	1789	22.7	PR	E306	PU-DEP U	1988	F40	81	49	Depleted	0.70%	
81-88-09-243	1799	22.7	PR	E380	PU-DEP U	1988	F40	81	49	Depleted	0.70%	
81-88-09-244	1796	22.7	PR	E305	PU-DEP U	1988	F40	81	49	Depleted	0.70%	
81-88-09-245	1793	22.7	PR	E491	PU-DEP U	1988	F40	81	49	Depleted	0.70%	
81-88-09-246	1809	22.7	PR	E535	PU-DEP U	1988	F40	81	50	Depleted	0.70%	
81-88-09-247	1811	22.7	PR	E503	PU-DEP U	1988	F40	81	50	Depleted	0.70%	
81-88-09-248	361	22.7	PR	E389	PU-DEP U	1988	F40	81	10	Depleted	0.70%	
H-014	679	6.14	10L	H014	PU-DEP U	1976	F40	88	1000	Depleted	0.66%	
H-018	679	6.14	10L	H018	PU-DEP U	1976	F40	88	2000	Depleted	0.66%	
H-022	678	6.14	10L	H022	PU-DEP U	1976	F40	88	1000	Depleted	0.66%	
H-026	680	6.14	10L	H026	PU-DEP U	1976	F40	88	2000	Depleted	0.66%	
H-037	683	6.14	10L	H037	PU-DEP U	1976	F40	88	1000	Depleted	0.66%	
H-047	659	6.14	10L	H047	PU-DEP U	1976	F40	88	1000	Depleted	0.66%	
H-059	679	6.14	10L	H059	PU-DEP U	1976	F40	88	2000	Depleted	0.66%	
H-063	681	6.14	10L	H063	PU-DEP U	1976	F40	88	1000	Depleted	0.66%	
H-066	679	6.14	10L	H066	PU-DEP U	1976	F40	88	2000	Depleted	0.66%	
H-070	678	6.14	10L	H070	PU-DEP U	1976	F40	88	1000	Depleted	0.66%	
H-071	677	6.14	10L	H071	PU-DEP U	1976	F40	88	1000	Depleted	0.66%	
H-076	682	6.14	10L	H076	PU-DEP U	1976	F40	88	1000	Depleted	0.66%	
H-077	678	6.14	10L	H077	PU-DEP U	1976	F40	88	2000	Depleted	0.66%	
H-082	680	6.14	10L	H082	PU-DEP U	1976	F40	88	1000	Depleted	0.66%	
H-085	680	6.14	10L	H085	PU-DEP U	1976	F40	88	2000	Depleted	0.66%	
R-209	657	6.14	10L	R209	PU-DEP U	1976	F40	88	1000	Depleted	0.66%	
R-228	433	6.14	10L	R228	PU-DEP U	1976	F40	88	1000	Depleted	0.66%	
R-232	655	6.14	10L	R232	PU-DEP U	1976	F40	88	2000	Depleted	0.66%	
R-235	649	6.14	10L	R235	PU-DEP U	1976	F40	88	1000	Depleted	0.66%	
R-243	654	6.14	10L	R243	PU-DEP U	1976	F40	88	1000	Depleted	0.66%	

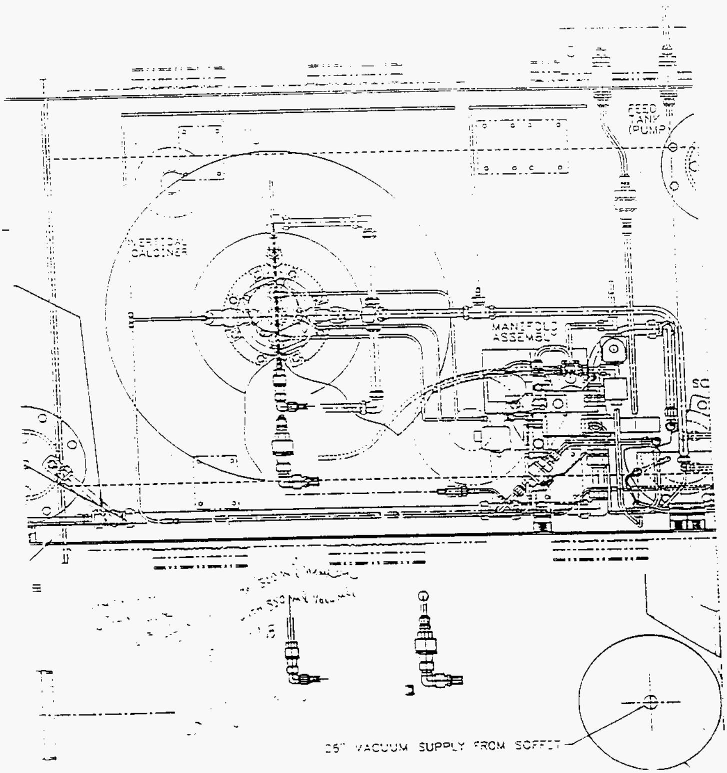
R-338	660	6.14	10L	R338	PU-DEP U	1976	F40	88	2000	Depleted	0.66%
R-379	678	6.14	10L	R379	PU-DEP U	1976	F40	88	2000	Depleted	0.66%
R-381	664	6.14	10L	R381	PU-DEP U	1976	F40	88	2000	Depleted	0.66%
R-400	647	6.14	10L	R400	PU-DEP U	1976	F40	88	1000	Depleted	0.66%
R-466	659	6.14	10L	R466	PU-DEP U	1976	F40	88	2000	Depleted	0.66%
R-518	658	6.14	10L	R518	PU-DEP U	1976	F40	88	2000	Depleted	0.66%
R-545	656	6.14	10L	R545	PU-DEP U	1976	F40	88	1000	Depleted	0.66%
R-560	654	6.14	10L	R560	PU-DEP U	1976	F40	88	2000	Depleted	0.66%
R-561	654	6.14	10L	R561	PU-DEP U	1976	F40	88	1000	Depleted	0.66%
R-562	656	6.14	10L	R562	PU-DEP U	1976	F40	88	2000	Depleted	0.66%
R-565	655	6.14	10L	R565	PU-DEP U	1976	F40	88	1000	Depleted	0.66%
R-568	656	6.14	10L	R568	PU-DEP U	1976	F40	88	2000	Depleted	0.66%
R-569	663	6.14	10L	R569	PU-DEP U	1976	F40	88	1000	Depleted	0.66%
R-571	660	6.14	10L	R571	PU-DEP U	1976	F40	88	1000	Depleted	0.66%
R-574	656	6.14	10L	R574	PU-DEP U	1976	F40	88	2000	Depleted	0.66%
R-576	653	6.14	10L	R576	PU-DEP U	1976	F40	88	1000	Depleted	0.66%
R-577	658	6.14	10L	R577	PU-DEP U	1976	F40	88	2000	Depleted	0.66%
R-579	661	6.14	10L	R579	PU-DEP U	1976	F40	88	2000	Depleted	0.66%
R-581	663	6.14	10L	R581	PU-DEP U	1976	F40	88	2000	Depleted	0.66%
81-88-09-241	342	11.86	PR	E478	PU-ENR U	1988	F00/F70	81	375	Enriched	0.73%
81-88-09-242	342	11.86	PR	E603	PU-ENR U	1988	F00/F70	81	375	Enriched	0.73%
81-88-09-249	249	11.86	PR	E341	PU-ENR U	1988	F00/F70	81	247	Enriched	0.73%
81-88-09-250	134	11.86	PR	E383	PU-ENR U	1988	F00/F70	81	147	Enriched	0.73%
97-74-12-606	19	12	10L	R438	PU-ENR U	1974	F70	97	18	Enriched	1.7%
97-74-12-607	19	12	10L	R278	PU-ENR U	1974	F70	97	18	Enriched	1.7%
97-74-12-608	18	12	10L	R219	PU-ENR U	1974	F70	97	17	Enriched	1.7%
97-74-12-609	18	12	10L	R217	PU-ENR U	1974	F70	97	17	Enriched	1.7%
97-74-12-610	19	12	10L	R462	PU-ENR U	1974	F70	97	17	Enriched	1.7%
97-75-01-315	22	12	10L	R493	PU-ENR U	1975	F70	97	154	Enriched	0.72%
97-75-01-316	23	12	10L	R537	PU-ENR U	1975	F70	97	51	Enriched	1.27%
97-75-01-317	18	12	10L	R341	PU-ENR U	1975	F70	97	69	Enriched	1.00%
97-75-01-318	19	12	10L	R503	PU-ENR U	1975	F70	97	78	Enriched	1.27%
97-75-01-319	29	12	10L	R555	PU-ENR U	1975	F70	97	89	Enriched	5.47%
97-75-03-359	22	12	10L	R512	PU-ENR U	1975	F70	97	72	Enriched	1.20%
97-75-03-360	22	12	10L	R247	PU-ENR U	1975	F70	97	60	Enriched	3.98%

97-75-03-361	21	12	10L	R412	PU-ENR U	1975	F70	97	71	Enriched	3.30%
97-75-03-362	23	12	10L	R538	PU-ENR U	1975	F70	97	56	Enriched	2.20%
97-75-03-363	21	12	10L	R229	PU-ENR U	1975	F70	97	65	Enriched	1.08%
97-75-03-392	20	12	10L	R300	PU-ENR U	1975	F70	97	62	Enriched	1.08%
97-75-05-459	23	12	10L	R450	PU-ENR U	1975	F50/F70	97	62	Enriched	0.72%
97-75-05-460	21	12	10L	R539	PU-ENR U	1975	F70	97	69	Enriched	1.03%
97-75-05-461	22	12	10L	R234	PU-ENR U	1975	F70	97	80	Enriched	0.83%
97-75-05-463	24	12	10L	R567	PU-ENR U	1975	F70	97	127	Enriched	0.83%
97-75-05-464	46	12	10L	R244	PU-ENR U	1975	F70	97	81	Enriched	0.72%
97-75-05-465	12	12	10L	R358	PU-ENR U	1975	F50/F70	97	82	Enriched	0.71%
97-75-05-466	28	12	10L	R269	PU-ENR U	1975	F70	97	79	Enriched	0.73%
97-75-09-713	17	12	10L	R272	Pu-EU	1975	F70	97	98	Enriched	1.03%
97-75-09-714	29	12	10L	R366	Pu-EU	1975	F70	97	75	Enriched	1.28%
97-75-09-715	20	12	10L	R386	Pu-EU	1975	F70	97	139	Enriched	0.76%
97-75-09-716	20	12	10L	R548	Pu-EU	1975	F70	97	71	Enriched	0.76%
97-75-09-717	19	12	10L	R371	Pu-EU	1975	F70	97	77	Enriched	1.01%
97-75-09-718	23	12	10L	R295	Pu-EU	1975	F70	97	60	Enriched	0.76%
97-75-12-880	20	12	10L	R499	Pu-EU	1975	F70	97	76	Enriched	0.79%
97-75-12-881	19	12	10L	R230	Pu-EU	1975	F70	97	66	Enriched	0.72%
97-75-12-882	22	12	10L	R336	Pu-EU	1975	F70	97	90	Enriched	0.79%
97-75-12-899	22	12	10L	R535	Pu-EU	1975	F70	97	71	Enriched	2.82%
97-75-12-900	20	12	10L	R432	Pu-EU	1975	F70	97	67	Enriched	7.46%
97-75-12-901	11	12	10L	R415	Pu-EU	1975	F70	97	42	Enriched	40.48%
97-75-12-902	21	12	10L	R570	Pu-EU	1975	F70	97	75	Enriched	0.79%
97-75-12-903	19	12	10L	R265	Pu-EU	1975	F70	97	64	Enriched	9.45%
97-75-12-904	15	12	10L	R556	Pu-EU	1975	F70	97	63	Enriched	9.45%
97-74-11-573	18	12	10L	R202	PU-NAT U	1974	F50	97	49	Natural	
97-74-11-574	18	12	10L	R218	PU-NAT U	1974	F50	97	50	Natural	
97-74-11-575	19	12	10L	R540	PU-NAT U	1974	F50	97	53	Natural	
97-74-11-576	17	12	10L	R299	PU-NAT U	1974	F50	97	47	Natural	
97-74-11-577	18	12	10L	R558	PU-NAT U	1974	F50	97	50	Natural	
97-75-05-462	22	12	10L	R279	PU-NAT U	1975	F70/F50	97	70	Natural	
97-75-12-879	11	12	10L	R505	PU-NAT U	1975	F70/F50	97	68	Natural	
TOTALS =	47805								62710		
ITEMS =	100										

ATTACHMENT 4. PRELIMINARY DRAWINGS

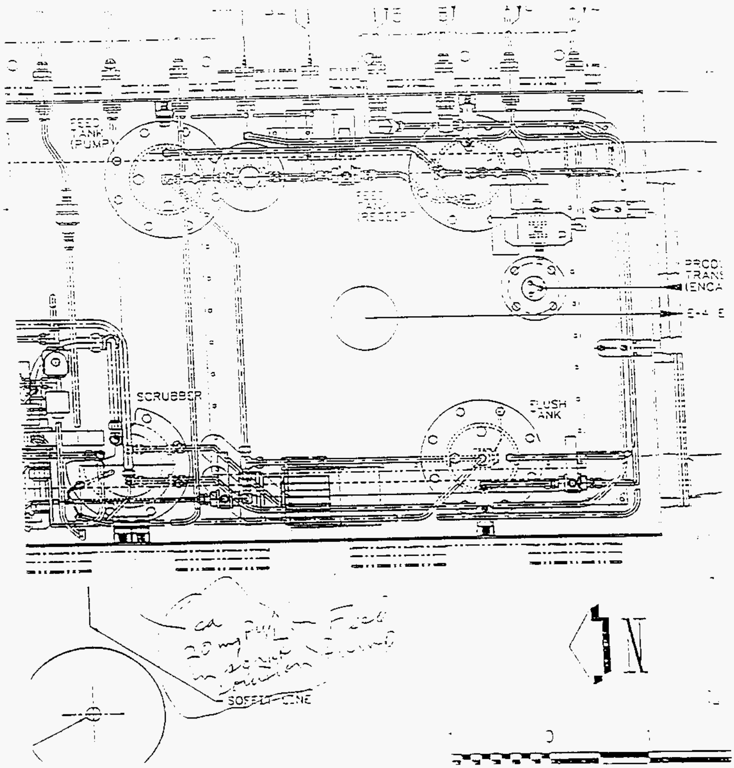
Preliminary Drawing A
Top-Down View of Section of Glovebox Containing the Calciner.

Dimensions derived from "scaling" are taken from this drawing. Scale developed from the assumption of a 15.24 cm (6 in.) ID of the tanks (inner dashed circle).



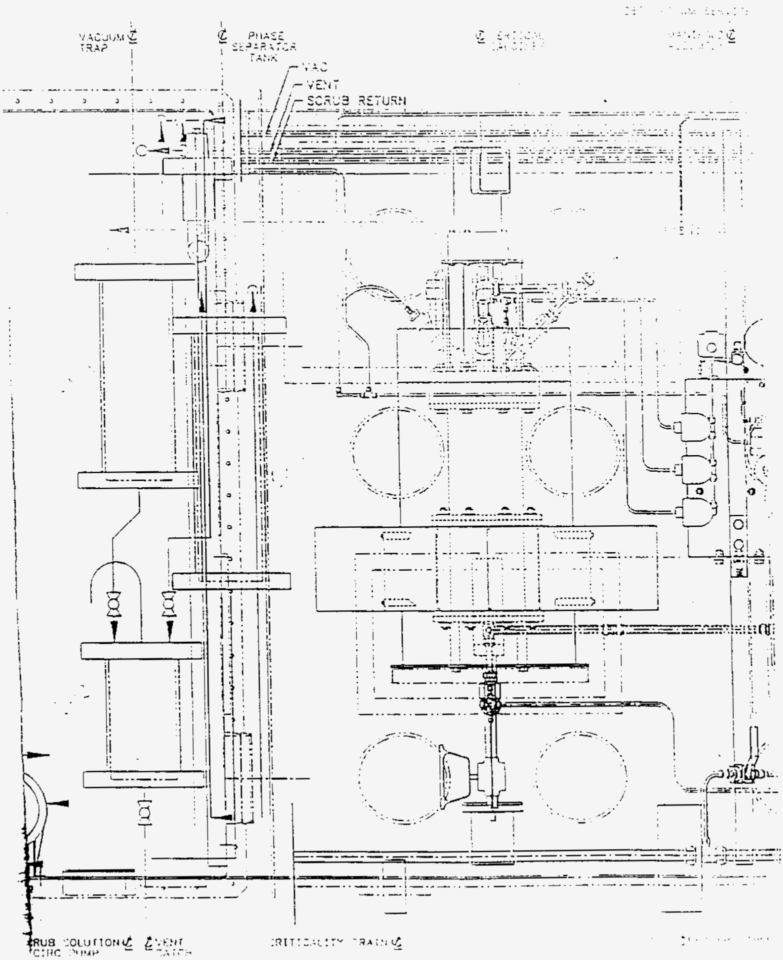
Preliminary Drawing A
Top-Down View of Section of Glovebox Containing Feed, Scrubber, and Flush Tanks.

Dimensions derived from "scaling" are taken from this drawing. NOTE: THE SCALE GIVEN IN THE DRAWING IS ERRONEOUS. Scale for the analysis developed from the assumption of a 15.24 cm (6 in.) ID of the tanks (inner dashed circle).



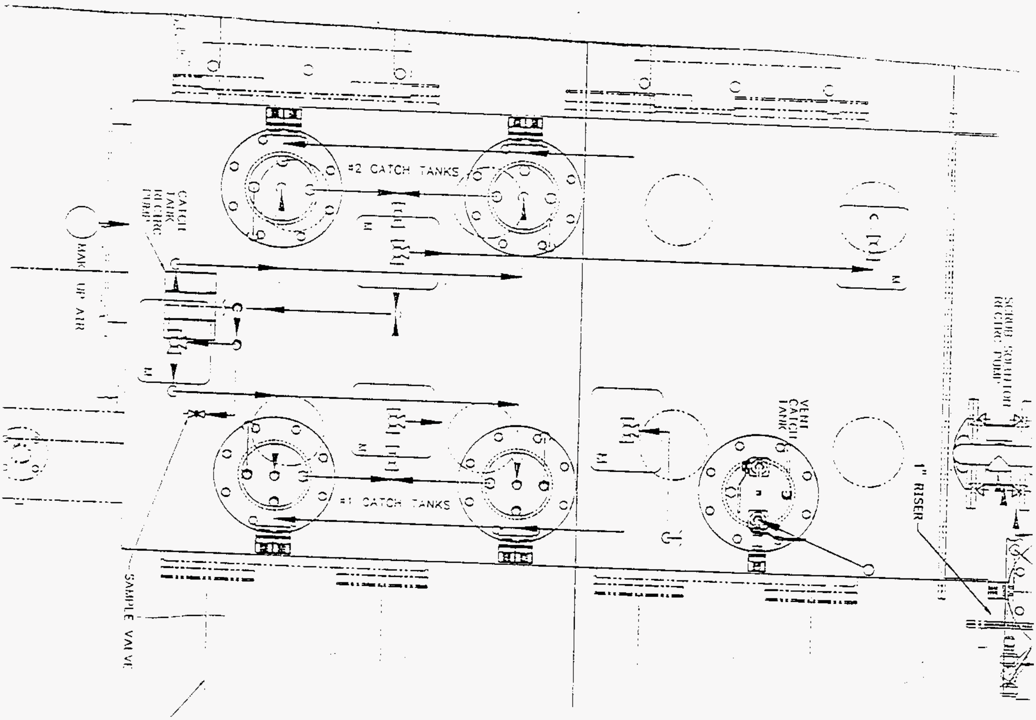
Preliminary Drawing A
Side View of Section of Glovebox Containing Calciner.

Dimensions derived from "scaling" are taken from this drawing. Scale developed from the assumption of a 15.24 cm (6 in.) ID of the tanks (inner dashed circle).

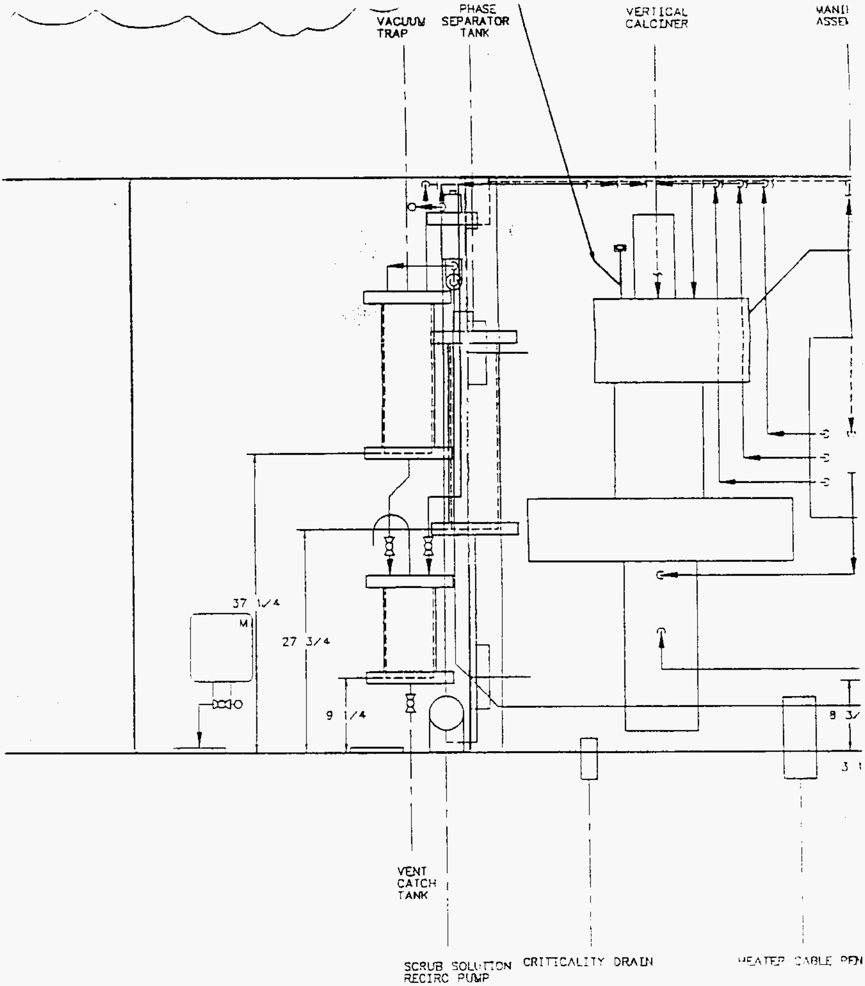


Preliminary Drawing A
Top-Down View of Waste Section of Glovebox.

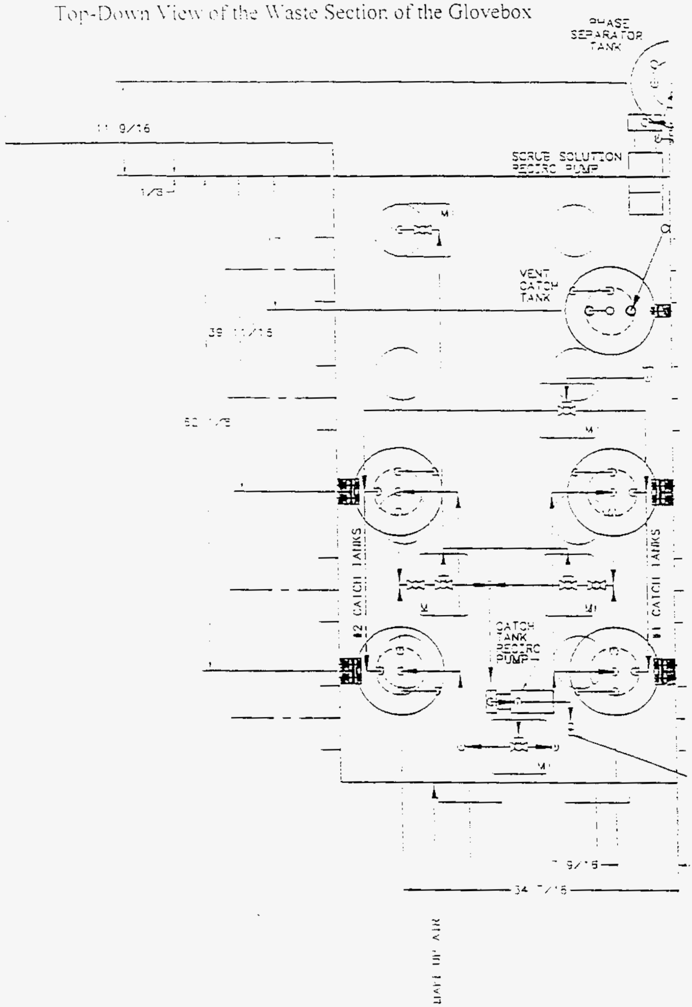
Dimensions derived from "scaling" are taken from this drawing. Scale developed from the assumption of a 15.24 cm (6 in.) ID of the tanks (inner dashed circle).



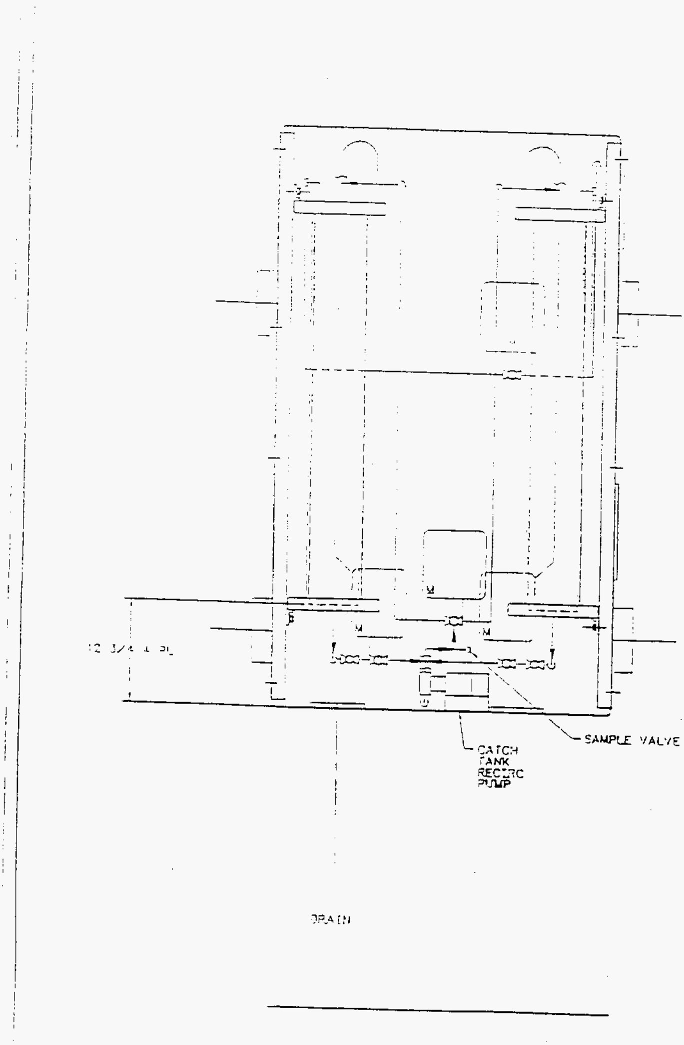
Preliminary Drawing B
Side View of the Section of the Glovebox Containing the Calciner



Preliminary Drawing B
Top-Down View of the Waste Section of the Glovebox



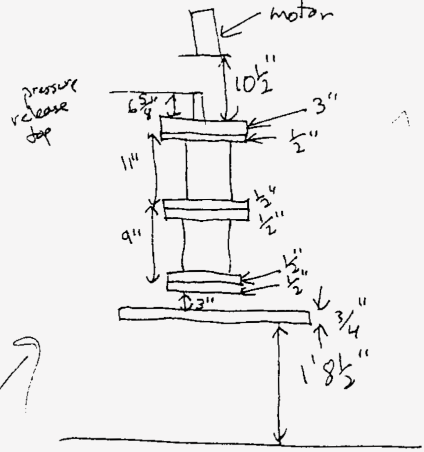
Preliminary Drawing B
Side View of the Waste Section of the Glovebox

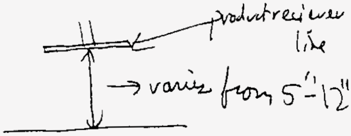


ATTACHMENT 5. HAND MEASUREMENTS TAKEN BY K.E. HILLESLAND AND RECEIVED FROM J.F. DURNIL BY PHONE, 3/12/97

3/12/97

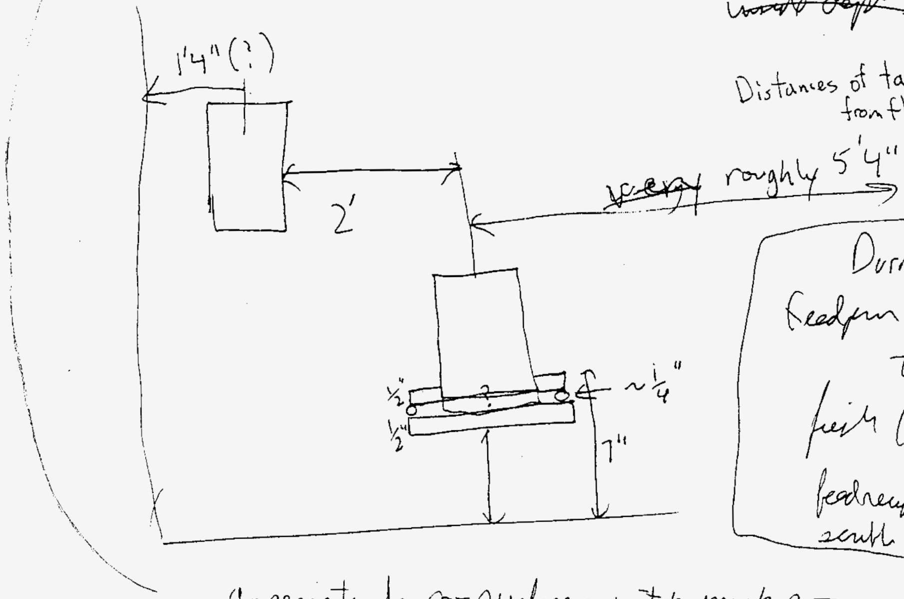
Found the following information: at Fab shop





~~inside depth~~ 6" deep.

Distances of tanks from floor



Durnil (from phone conference)

feedpump 6 1/4" tank

finish 16 3/8"

feedreceipt 33 3/8"

scrubb 12 3/4"

Appears to be no surfaces with much room on column for stacking → although must investigate insulation. Feed tanks sort of have room.

Measurements received from telephone conversation with J.F. Durnil

Distances of bottom of tanks from floor

Feed Pump Tank	6 1/4"
Flush Tank	16 7/8"
Feed Receipt Tank	33 3/8"
Scrubber Tank	12 3/4"

Distances of tanks from south, inner wall of glovebox

Feed Pump Tank	43 3/8"
Flush Tank	15 3/4"
Feed Receipt Tank	15 5/8"
Scrubber Tank	47 1/2"

Overall internal glovebox dimensions for calciner section (above rounded part on floor)

length: 103 5/8"
width: 41 1/4"

ATTACHMENT 6. CORRESPONDENCE CONCERNING MAXIMUM CREDIBLE FEED SOLUTION SPILL

Author: Gregory G Bergquist at ~HANFORD03B
Date: 3/3/97 10:55 AM
Priority: Normal
TO: Karl E Hillesland at ~HANFORD07A
Subject: Pu Liquid on VC Glovebox Floor
------------------------------ Message Contents ------------------------------

Karl,

I searched for answer or explanation to your question regarding the release of concentrated Pu solution onto the glovebox floor from transfer operations. The flowsheet document covers most of the information.

The Feed Receipt Tank (FRT) will have a 10 liter working volume. The tank is equipped with a conductivity probe (LEH-230-J) which will shut off the transfer route by electrically (EV-230-J) closing the air supply to an air operated (Air-to-Open) ball valve (BV-230-J). The liquid from HC-227S will be pumped to HC-230C-2. Estimated line holdup after the pump is turned off and BV-230-J is closed will be about 9 liters (high point in transfer line to HC-230C-2) and about 9 liters (high point in transfer line to HC-227S).

Once the FRT is filled it will be gravity drained through a diaphram operated valve (DOV-230-F) to the Feed Pump Tank (FPT) which will also have a 10 liter working volume. The FPT is equipped with a high liquid level interlock which will close the air supply to the DOV by electrically shutting solenoid valve (EV-230-F) thus stopping the flow from the FRT.

The Process Engineering group is planning for operations to load-in up to 4 PR Cans (8.5 liters) into a single batch tank (45 liters) in glovebox HC-227S. An existing CSER for HC-227S supports this activity. Loading in the 4 PR cans and associated dilute acid flush to grossly clean the PR can would give us about a 40-45 liter feed source in HC-227S for transfer to the FRT in glovebox HC-230C-2.

If the 1/2" transfer line leaks the 3" encasement piped is sloped to either drain back into HC-227S or HC-230C-2 depending on where the leak would occur. The leak would go directly to floor of either glovebox. So under unusual conditions we could possibly have 45 liters in a HC-227S batch tank and about 9 liters held up in the transfer line that could be pumped to the floor of HC-230C-2. There will always be about 9 liters of solution that will remain on the HC-227S side of the transfer line.

Additionally, glovebox HC-230C-2 will be equipped with a sump probe located underneath the FRT and FPT which will detect a leak if the solution depth on the floor reaches about 1/2".

We also have the human side of this entire evolution. The operations staff will be intimately involved with all plutonium solution transfers. They will watch it like a hawk. I can't overemphasize this point. We will also perform a material balance after each transfer to assure that the solution is accounted for.

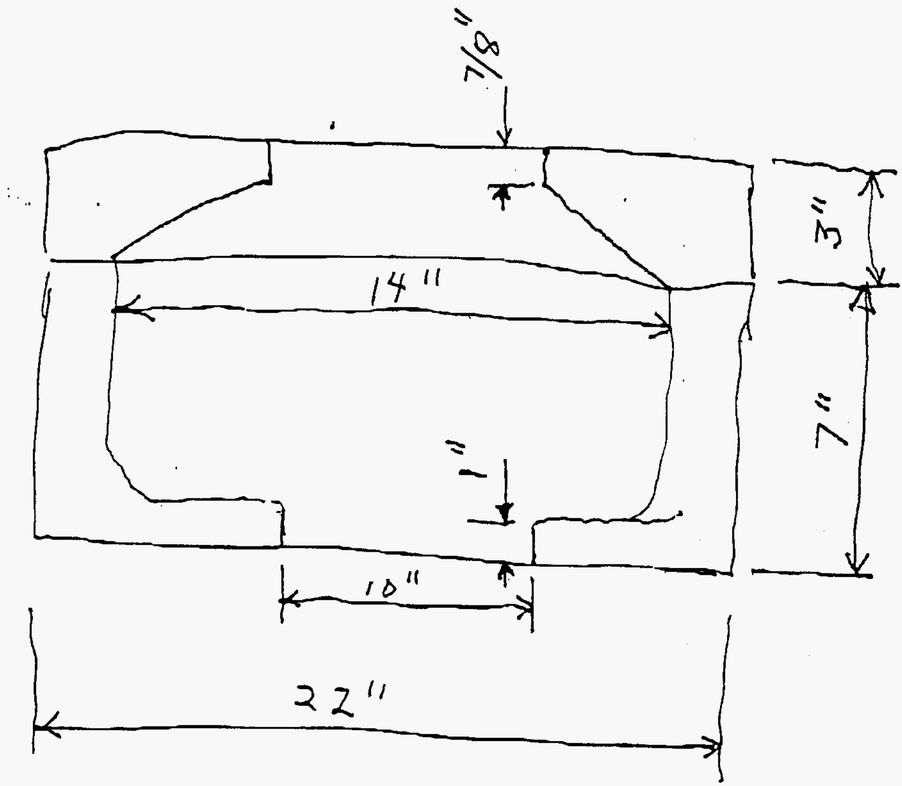
Greg B.

ATTACHMENT 7. HAND SKETCH OF LOWER INSULATION ON CALCINER

FROM 4. 4.1997 14:21 P. 1

Post-it® Fax Note 7671

To K Hillesland	Date 4/4/97 # of pages ▶ 1
Co./Dept. FDNW/SPE	From Jerry Durnil
Phone # 373-4078	Co. BWHC
Fax # 376-6282	Phone # 373-2150
	Fax # 373-2752



ATTACHMENT 8. DIMENSIONS OF FILTERS AS MEASURED BY J.F. DURNIL

(Responses by J.F. Durnil to inquiries concerning dimensions given in italics)

Author: Jerome F (Jerry) Durnil at ~HANFORD03B
Date: 4/21/97 3:39 PM
Priority: Normal
TO: Karl E Hillesland at ~HANFORD07A
CC: Jerome F (Jerry) Durnil
Subject: Re[3]: Dimensions I still need
------------------------------ Message Contents ------------------------------

Do you have the thickness of the bottom of the filter? (Model uses 1.5 in.)

Karl

Measured thickness is about 1 1/8" (1.125")

______________________________ Reply Separator ______________________________
Subject: Re: Dimensions I still need
Author: Jerome F (Jerry) Durnil at ~HANFORD03B
Date: 4/21/97 9:15 AM

I've been using some dimensions from the lab calciner criticality calculational models, but I don't know where they came from. Do you have the following?

Dimensions for the filter elements (inner and outer)

Filter Element dimensions, measured filter element with tape measure:

Outer Diam: 2"
Inner Diam: 1 7/16" (1.4375")
Total Length: 12.25"
Estimated insertion length: 11.25" filter length below their mounting flange.

Height of the "inner dome" in the calciner. I have drawing H-2-95609, which specifies a height for the cylindrical section (4.875 in.), and then specifies the domed portion as "cap, 4 in. sched 10S BTWLD", but I don't know what that means in terms of the height I want.

4-inch diameter buttweld pipe cap has a listed height of 2.5", Ref. Chem Engineer handbook, 5th Ed., Perry & Chilton, Table 6.26

Karl Hillesland
373-4078

DISTRIBUTION SHEET

To	From	Page 1 of ~~109~~ 1 KEH 9/4/97
Distribution	Criticality and Shielding	Date 8/28/97
Project Title/Work Order CSER 97-004: PFP Production Denitration Calciner System		EDT No. 621299
		ECN No. N/A

Name	MSIN	Text With All Attach.	Text Only	Attach./ Appendix Only	EDT/ECN Only
<u>B & W Hanford</u>					
G.G. Bergquist	T5-55	X			
J.F. Durnil	T5-55	X			
M.W. Gibson	T5-55	X			
C.M. Kronvall	T5-15	X			
J.L. Mejia	T5-08	X			
L.T. Nirider	T5-53	X			
S.E. Nunn	T5-11	X			
A.L. Ramble	T5-54	X			
<u>Fluor Daniel Hanford</u>					
S. Tsai	B1-19	X			
E.J. Krejci	B1-19	X			
<u>Fluor Daniel Northwest</u>					
K.D. Dobbin	H0-35	X			
D.G. Erickson	H0-35	X			
S.R. Gedeon	H0-35	X			
H.J. Goldberg	H0-35	X			
J. Greenborg	H0-35	X			
K.E. Hillesland	H0-35	X			
J.S. Lan	H0-35	X			
E.M. Miller	H0-35	X			
L.L. Pedersen (3)	H0-35	X			
R.H. Ruben	H0-35	X			
W.D. Wittekind	H0-35	X			
W.T. Watson	H0-31	X			
Central Files (Original +2)	A3-88	X			