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		* ADVANCE COPY									
1	1	Cog. Eng. T. Chiao	<i>T. Chiao</i>	8/22/94		CSR L. T. Nirider	<i>L. T. Nirider</i>	9-9-94		1	1
1	1	Cog. Mgr. J. W. Daughtry	<i>J. W. Daughtry</i>	9-7-94		CENTRAL FILES (2)		28-04			
		QA				OSTI (2)		28-07			
1	1	Safety S. E. Nunn	<i>S. E. Nunn</i>	9/15/94							
		Env.									
1	1	Peer Review A. L. Hess	<i>A. L. Hess</i>	9/2/94	HY-64						
1	2	Peer Review E. M. Miller	<i>E. M. Miller</i>	8/18/94							

18. T. Chiao <i>T. Chiao</i> Signature of EDT Originator	19. E. C. Vogt Authorized Representative Date 9/2/94	20. J. W. Daughtry <i>J. W. Daughtry</i> Cognizant Manager Date 9-7-94	21. DOE APPROVAL (if required) Ctrl. No. ☐ Approved ☐ Approved w/comments ☐ Disapproved w/comments
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RELEASE AUTHORIZATION

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Document Title: CSAR 81-001, Addendum 2 - Use of a Plexiglass Contamination Barrier in HC-227-T Hood

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This document was reviewed following the
procedures described in WHC-CM-3-4 and is:

APPROVED FOR PUBLIC RELEASE

* * * * *

WHC Information Release Administration Specialist:

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(Signature)

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9/19/94

(Date)

SUPPORTING DOCUMENT		1. Total Pages 811 ^{KW}
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5. Key Words Criticality Drains, Plexiglass Contamination Barrier, HC-227-T, PR can, L10, L-3 can APPROVED FOR PUBLIC RELEASE <i>U. Birchland 9/19/94</i>	6. Author Name: T. Chiao <i>T. Chiao</i> Signature 8D150/K6C1H Organization/Charge Code	
7. Abstract CRA performed a criticality safety evaluation to support a revision of Criticality Prevention Specification CPS-Z-165-80601 Rev./Mod. B/O allowing a plexiglass enclosure installed inside the HC-227-T hood as a contamination barrier. Such a contamination barrier can be placed inside the HC-227-T if it is equipped with adequate criticality drains.		
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9. Impact Level S		

MASTER

ADDENDUM 2 TO CSAR 81-001

Title: USE OF A PLEXIGLASS CONTAMINATION BARRIER IN HC-227T HOOD

Prepared by: Tang Chiao Date: 8/31/94
Engineer, Criticality and Radiological Analyses

Reviewed by: Edward M. Miller Date: 8-31-94
Engineer, Criticality and Radiological Analyses

Reviewed by: Allen Hess Date: 9/2/94
Engineer, Criticality and Radiological Analyses

Approved by: J. Daugherty Date: 9-7-94
Manager, Criticality and Radiological Analyses

INTRODUCTION AND SUMMARY

Plutonium Finish Plant (PFP) Engineering requested a criticality safety evaluation (Appendix 1) to support a revision of Criticality Prevention Specification CPS-Z-165-80601 allowing a plexiglass enclosure (PGE) to be placed inside the HC-227T hood as a contamination barrier.

The HC-227T hood is the receiving/transfer enclosure for Pu nitrate solution contained in Product Removal containers (PR Cans), L10 Containers (L10, FI-10, 10L) or L-3 Containers. Within the HC-227T, a 1.349 square meter (15 square foot) enclosure, PGE, (177.8 cm by 81.28 cm, i.e. 70 inches by 32 inches as shown in Figure 1) has been created to provide contamination control around the weighing scale. Two or more standard criticality drains shall be installed on this enclosure prior to beneficial usage.

The evaluation considered the normal process, spillage scenarios, waste/container accumulations within the enclosure, and interactions of Pu within the enclosure as well as other containers external to the enclosure.

The results from the criticality safety analysis by CRA shows that such a contamination barrier can be placed inside the HC-227T Hood if the PGE is equipped with adequate criticality drains. In addition, other limits as well as administrative controls listed in CPS-Z-165-80601 Rev./Mod. B/0 and CPS-Z-165-80010 Rev./Mod. C/1 shall also apply.

SYSTEM DESCRIPTION

Hood HC-227T is an open-faced hood located in room 227 in building 234-5Z. This hood is utilized for vacuum transfer (both loading and unloading) $\text{Pu}(\text{NO}_3)_4$ containers in conjunction with the adjacent glovebox, HC-227S. The

containers are normally placed in the open right hand side of HC-227T inside their respective outer container. The outer container (drum) is opened and the inner container (PR can or L10 bottle) removed by a chain lift and transferred to a scale which is located in the left hand side of HC-227T. The container is normally weighed prior to addition or removal of solution to obtain tare/gross weight data. After transfer of solution, the container is reweighed and placed in the outer container (drum) or discarded, in the case of a emptied L10 bottle.

Some of the solutions which were transferred may have dripped onto the floor and scales area. This frequently resulted in the spread of contamination to the entire room causing the room to remain continuously in an "on-mask" status. **In order to remedy this problem, Operations installed a plastic enclosure in the left half of the hood.** Significant spills to the floor are required to be removed prior to continuation of operations. Decontamination rags and empty (or full containers) are also to be removed prior to the next operation.

This enclosure measuring 81.28 cm X 177.8 cm X 198.12 cm (32" X 70" X 6'6") attaches to the upper portion of the hood on three sides and extends to the concrete floor. The wall of Room 227 serves as the back side of the enclosure. This enclosure is continuous on all sides and is sealed along all seams with RTV silicone sealant. The enclosure is essentially waterproof with the exception of the penetration in the top where PR cans would be lowered onto the scales.

A 2.54 cm (1") diameter hole has been made on the north (left) side of the enclosure approximately 2.54 cm (1") off the floor in order to provide some kind of drain for liquids inadvertently or accidentally introduced into the enclosure. **However, CRA required that sufficient official criticality drains including mesh to be installed on this enclosure. Such criticality drain(s) are shown necessary for criticality safety by this evaluation report. The bottom of criticality drains are suggested to be 1.27 cm (1/2 inch) above the floor to permit recovery of limited volumes of solution spilled prior to its' overflow into the occupied space in room 227.**

The plexiglass material is approximately 0.48 cm (3/16") thick and is reinforced with a double layer of material in some places in order to add stiffness. The material is entirely clear allowing good visibility into the inside.

ANALYSIS

Several situations or scenarios should be evaluated for HC-227T to ensure that the system is acceptably subcritical for both normal and accident conditions (container interaction, container/floor solution interaction, spillage unto the floor, water addition from fire fighting sprinklers, overbatching of containers).

Container Interaction

A container within the PGE will normally be on the scale or in transit; there is no provision for storage of full or empty containers in the enclosure. Only one container is to be processed at a time through the HC-227T hood, so container interaction with another one in the drum loading position would be unusual. It would be acceptably subcritical because of the built in spacing of the enclosure/drum dimensions. Similarly, if a similar container were outside the enclosure in the room, there would be adequate neutron leakage that the two containers would be subcritical even though nearly in contact with each other on the inside and outside of the enclosure. Placement of another filled container also adjacent, would constitute multiple errors (double contingencies) and is not considered a credible accident.

Container/Floor Solution Interaction

Although solution spilled to the floor is to be cleaned up prior to continued operation, it is credible that some small amount of solution could be on the enclosure floor simultaneous to placing a loaded container into the enclosure. If the enclosure is to be restricted to a maximum of 5 kg Pu total (WHC-SD-CP-OSR-10, Plutonium Finishing Plant Operational Safety Requirement, Administration Control 5.22), it would take multiple inattention errors to have both a loaded container in the enclosure and significant Pu on the floor. The container is also to be on the scale platform normally and not on the floor, thus minimizing interaction.

Spillage unto the Floor

If the solution from a 10 liter container with a concentration of up to 450 g/l Pu were spilled to the floor, several different arrangements would need to be evaluated.

If the floor were bare, free of other solution and "solids accumulations", the 1.445 square meter (15.6 square feet) floor area could have up to 290 grams Pu per square foot areal concentration, but a depth of only 0.711 cm (0.28 inches) keeps the system subcritical because it is too shallow. However, if additional water were introduced (e.g. a fire or an earthquake activate the room fire sprinkler), the system reactivity could become excessive. Data found in ARH-600 (Reference 1) shows an infinite slab minimum critical areal density of $\approx 240 \text{ g/ft}^2$ with full water reflection (ARH 600 III.A.8(100)-3). Thus, a "maximum acceptable" areal density would be less than 240 g/ft^2 because the allowed k_{eff} must not exceed 0.95 (to provide a 5% of k_{eff} safety margin). Therefore, installation of criticality drain(s) is necessary to maintain double contingency, assurance of subcriticality.

Criticality Drains

Free-flowing criticality drains are used routinely to ensure that a Pu-bearing solution depth does not become excessive for criticality safety. Based upon the data of ARH-600, a solution depth of 5.04 cm (2 inches) is acceptably subcritical in contact with a concrete floor as determined below.

According to ARH 600, III.A.5(100)-5, for an infinite slab, which is more conservative than a finite slab, the $k_{eff} = 1.00$ if the depth of the solution slab is about 6.553 cm (2.58 inches) with a solution of Pu concentration at 450 gm/l under 1" H₂O and 10" concrete reflection. The $k_{eff} = 0.98$ if the depth of the same solution is 6.325 cm (2.49 inches). Chart II.B.1-10 in ARH-600 (Reference 2) shows that if a solution slab thickness is in the range between 85% to 100% of its minimum criticality thickness, i.e. 6.553 cm (2.58 inches) in the current case, the k_{eff} decreases almost linearly with the decrease of slab thickness for fully reflected Pu-H₂O with 3 wt.% of ²⁴⁰Pu. The linear relationship is expected to be similar for Pu-H₂O with 0 wt.% of ²⁴⁰Pu (Reference 3). Extrapolation of the ARH-600, Chart III.5(100)- 5 curves for $k = 1.0$ and $k = 0.98$, then yields a thickness of 5.98 cm (2.36 inches) for a k_{eff} of 0.95. Therefore, if the depth of Pu solution can be kept less than 5.04 cm (2 inches, 76.9% of the minimum critical thickness), the solution with a concentration of 450 g/l of Pu on the floor will assuredly be subcritical ($k_{eff} < 0.950$) with the 10" concrete and 1" H₂O reflection conditions.

The criticality drain must be located and sized such that the depth of solution in the PGE area does not exceed the 5.04 cm (2 inches), for the maximum foreseeable solution addition rate.

Criticality drains are usually at least 1.27 cm (1/2 inch) off the floor to permit recovery of small leakages from going out into a room or other area.

"Solids Accumulations" and "Good Housekeeping"

If "solids accumulations" such as rags, plastic bags, gloves, or old containers can not be precluded, then the full 1.39 square meter (15 square feet) of floor area can not be ensured. When "solids accumulations" reduce the effective floor area for solution spillage, the maximum acceptable Pu mass drops quickly. If the slab were only 154.8, 116.1, or 96.8 square centimeters (24, 18, or 15 square inches), the acceptable values would be only 1.28, 0.82 or 0.642 kg Pu, respectively (Appendix 2). Because of this potential increasing in reactivity, "Good Housekeeping" as well as adequate criticality drain(s) becomes mandatory.

A similar high reactivity would occur if the Pu container were to spill into a wastebasket or a 18.9 liters (5-gallons) pail sized container. Tools are frequently carried in pails or solid walled baskets. Such pails must not be introduced to an area such as HC-227T hood or PGE area whenever Pu might be spilled into it.

Best practices preclude solid walled containers and minimize addition of tool containers into Pu processing areas. Plastic bags for cleanup of hood waste should also be kept to smallest diameter practicable and removed quickly from the HC-227T and PEG area. They should only be used as specified in an operation procedure or approved work plan as specified in CPS-Z-165-80601 Rev./Mod. B/0.

In order to preclude the potential blockage of the drains by "solid accumulations", CRA suggests two or more drains be provided dependent upon size and other controls.

Double Batching

The normal accident contingency for double batching may be of less consequence for an otherwise controlled enclosure. If the solution concentration in PR Can or L10 exceeds the allowed limit, the individual container can still safely contain the mass (CSAR 79-011 and CSAR 79-30). If this solution were present in the sump (enclosed floor), the depth would be restricted by the container volume (10 liters) and the functional criticality drain(s) and, therefore, the sump still remains subcritical (ARH 600 III.A.8(100)-3). If fire-fighting water were added, the situation would be unacceptable without adequate criticality drains.

Fire-fighting Water

In addition to the sprinkler(s), one has to consider the additional water from fire-fighting. In room 227 and HC-227T area, fire-fighting is "Category C" which restricts the forms of water for fire-fighting are high expansion foam, automatic sprinkler systems, limited water-volume systems, or hose fog nozzles. The size of criticality drains should be large enough to handle the "Category C" fire-fighting water.

Summary of Analyses

The several scenarios show that criticality drain(s) are appropriate to preclude a criticality accident for both normal and accident conditions, when fire-fighting water addition is also considered. Good Housekeeping and Pu material balances are appropriate, but of lesser impact for criticality safety. The addition of the "Contamination Barrier" enclosure is acceptable with the presence of both engineered and administrative controls as stated in CPS-Z-165-80601 and CPS-Z-165-80010.

Reviewers' Comments

1st Reviewer

E. M. Miller of Criticality Radiological Analyses carried out one of the two independent, technical reviews of "CSAR 81-01 Addendum 2, Use of A Plexiglass Contamination Barrier In HC-227T" and provided the following comments.

The criticality safety evaluation was reviewed for technical adequacy for inclusion of a contamination barrier in the hood HC-227T. The references and logic were confirmed to establish the intended conclusions. The safety assurance of the "Container Interaction" and "Criticality Drains" sections are augmented in the paragraphs below. Some editorial comments and suggested clarifications were incorporated into the text.

The "Container Interaction" section argues that having two or more fissile containers adjacent is not credible. The margin of subcriticality is much larger than inferred from this argument. For standard PR cans, L-10's, 10L's, and FL-10's, the CPS-Z-165-80100, Rev./Mod J-1 allows a storage array of at least 40x40x1 containers. These are the same containers considered by this addendum. The size of room 227 is too small to contain a 40x40x1 array, so there is no challenge to criticality safety from arrangements of these containers.

The graph III.A.5(100)-5 from ARH-600 shows that a slab of plutonium and water 2" thick or less reflected by 1" of water on one side and 10" of concrete on the other side is significantly subcritical for all concentrations of 1000 g Pu/l or less. The maximum anticipated plutonium concentration is considerable less than this. Assuming the contents of a double batched L-10 containing 9 kg of plutonium spread over only half the floor area inside the contamination barrier, $15/2 = 7.5$ sq. ft., for a 2" deep slab, the concentration would be 254 g Pu/l.

A 2" slab of water even over only half the floor area is a volume of 35 l. There is at most 10 l from a 10-L container inside the HC-227T Hood. To exceed 2", external water from sprinklers would have to enter the hood. J. E. Hammelman calculated in ARH-2406 entitled "Z PLANT SPRINKLER SYSTEM, CRITICALITY SAFETY ANALYSIS REPORT," dated January 7, 1974, a 6 gpm entrance rate of sprinkler water into the glovebox HC-227S. The 6 gpm was the maximum entrance rate and was the most common calculated entrance rate for sprinkler water entering gloveboxes during an upset event. Assuming that 6 gpm could enter the hood as is calculated for the adjacent glovebox HC-227-S, the criticality drains would need to allow a out flow of 6 gpm to limit the solution to a 2" depth in the bottom of the hood. The George D. Lehmkuhl report REF-2222 (TID-4500-R60) entitled "CRITICALITY DRAIN PERFORMANCE STUDY" dated August 29, 1974, shows in Figure 3 that a flow rate of 6 gpm is sustained in a 2" diameter side drain with a 1.4" head of water above the bottom of the hole. A larger diameter drain needs a smaller head for a flow rate of 6 gpm. Therefore, a 2" diameter criticality drain placed so its bottom edge is within 0.6" of the floor would limit the accumulation of water to a depth of 2" within the contamination barrier enclosure.

2nd Reviewer's Comments

A. L. Hess of Criticality and Radiological Analyses also reviewed the drafts prepared for this CSER. The reference data cited by both the author and 1st reviewer were reviewed and found appropriate. Recommended text clarifications have been incorporated. Some additional technical comments are warranted, as presented below.

With regard to an overbatching contingency, it is highly unlikely that there would be a full double batch (9 kg Pu) in a 10-L or other type container placed into glovebox 227T; this would imply a concentration of 900 g Pu/l, whereas the most that could be expected would be 600 g Pu/l, about where it is more of a slurry/sludge than a solution.

The arguments presented support the report findings, that with the prescribed criticality drains installed there is double contingency assurance against an inadvertent criticality. It requires activation of the room fire-suppression sprinkler to create a criticality hazard, but with the open face hood design water entry is more probable than for gloveboxes. Thus, two drains are recommended to better preclude blockage. Also, the recommended vertical positioning of the drain (0.6 inches from floor to bottom of hole) will accommodate spilling of a full container without overflow to the room, in keeping with the objective of the enclosure.

The question about the impact of earthquakes on the criticality safety controls has been raised for several of the gloveboxes in PFP. The HC-227T glovebox was determined to be "seismically qualified" in recent seismic-impact studies, meaning no structure failures are expected in a DBE. The glovebox is thus not likely to topple. In view of the way the PGE is attached to the glovebox and to the floor, no damage to the enclosure is thus probable due to the shaking. However, shuffling of the equipment or container within could impact the walls of the PGE. In this case the most likely result would be breaking the caulk seals to the floor of the room, making the PGE a "noncontainer" with respect to criticality safety.

References

1. ARH-600, "CRITICALITY HANDBOOK", Vol. II, R.D. Carter, et. al.. Atlantic Richfield Hanford Co., May 23, 1969
2. ARH-600, "CRITICALITY HANDBOOK", Vol. I, R.D. Carter, et. al.. Atlantic Richfield Hanford Co., May 23, 1969
3. W. E. Matheison, private communication

Figure 1

HC-227T HOOD ARRANGEMENT

(Not to Scale)

Westinghouse
Hanford Company

Appendix 1

Internal
Memo

From: PFP Engineering
Phone: 373-3180 T5-53
Date: June 6, 1994
Subject: CPS-Z-165-80601, ANALYSIS TO SUPPORT THE USE OF A PLEXIGLASS
CONTAMINATION BARRIER IN HC-227T

15500-94-LTN-038

To: D. E. Friar R3-01
E. M. Miller H4-64

cc: G. B. Chronister T5-04
J. F. Durnil T5-55
M. W. Gibson T5-55
C. M. Kronvall T5-53
W. E. Matheison S6-19
L. H. Rodgers T5-53

Reference: Criticality Safety Analysis Report 81-001

In order to control surface contamination in the area of the scale located in Hood HC-227T, a plexiglass enclosure has been installed. This enclosure consists of three plexiglass sheets approximately 3 1/2 feet high enclosing an area of approximately 3 feet by 7 feet. The edges and the bottom at it's junction with the floor are sealed with RTV. The enclosure has been made a non-container under the definitions described in Section J.2. of the Criticality Prevention Specification CPS-Z-165-80010, "General Limits" by drilling appropriate holes near the bottom. It is proposed to cover the holes in the enclosure with a "welding paper" to contain the contamination. This paper essentially dissolves upon contact with a liquid, thus allowing the free flow of any accumulated solution from the bottom of the enclosure.

Please prepare an addendum to the above referenced criticality safety evaluation which addresses the presence of such an enclosure for the proposed 10-L container handling in HC-227S and HC-227T.

L. T. Nirider

L. T. Nirider
Criticality Safety Representative

kmg

Appendix 2

wpdata\BG2K95PU.WEM

JULY 25, 1994

362 DAYS AGO, July 28, 1993, I penned some calculations for $k_{\text{effective}}=0.95$, for Pu(100)-H₂O, as shown on Page 2, below.

If the standard equation for geometric buckling for a slab is used with these assumed values of B_g^2 , values for depth, Volume and Mass can be calculated for finite slabs rather than infinite slabs.

Note that although reduced dimensions of finite slabs increase the allowable depths, the volumes/mass contained in the smaller space is greatly reduced.

$$B_g^2 = \pi^2 \sum 1/(a+\lambda_1+\lambda_2)^2 + 1/(b+\lambda_3+\lambda_4)^2 + 1/(c+\lambda_5+\lambda_6)^2$$

where a, b, and c are slab dimensions in cm, and the lambdas are the extrapolation distances for the different faces of the slabs. Note that 2 of the 6 extrapolation distances would be for concrete if evaluating 227-T, as the floor and 1 wall are concrete.

Concrete has a higher extrapolation distance than water!!

Whereas full water reflection (top and bottom) for an infinite slab would have a minimum critical areal concentration of 240 to 250 grams Pu per square foot, full concrete reflection could have 211 grams per square foot critical (RD Carter, 1978).

The following Pu masses are calculated for reduced slab sizes, to compare to minimum critical mass of $240 \text{ g/ft}^2 \times 15.55 \text{ ft}^2 = 3.733 \text{ kg}$ for 227-T area noted.

Pu(100)-H₂O slab, concrete on bottom and 1 side, full water on 3 sides, bare on top. Different Pu concentrations and square slab dimensions

Pu g/l	24" square Pu, kg	18" square Pu, kg	15" square Pu, kg
10	1.61	1.66	∞
15	1.25	1.15	0.692
20	1.28	0.82	0.643
30	1.52	0.945	0.722
50	2.08		

The low mass numbers for small dimension slabs (boxes) illustrate the need to prevent debris from forming such volumes into which solution could be spilled.

Will 3-2528