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7. Abstract A criticality safety review is presented for the use of plastic-sheet glovebags for the operations of draining demisters on the 26-inch vacuum system headers. A criticality drain is required because of the possibility for spilling liquid of sufficient volume and fissile content for criticality. It is recommended that the glovebag design include a rigid, 2ft x 2ft floor with a central drain feeding a geometrically favorable spill-catch vessel, plus a screen grid above the bottom for drain protection.		
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CSER 94-011

Title: Use of Glovebags for Demister Draining Operations

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1. INTRODUCTION AND SUMMARY

The 26-inch vacuum system for the Plutonium Finishing Plant includes a number of demister assemblies in its pipe network to inhibit the transfer of liquid or vapors all the way downstream into the HEPA filters and pumps serving the system. As the HEPA filters are not geometrically favorable for criticality safety, the demisters also serve as fissile material traps. There are separate CPS limits on fissile mass accumulations for the body and drip leg of any demister, at maximums of 400 g and 1000 g Pu, respectively. Also, the liquid holdup in any drip leg is controlled to 4.7 liters, maximum.

The system operational program has requirements to periodically inspect the demisters, including assays of Pu content and gauging the liquid level in the driplegs. At given mass and/or liquid level setpoints there are also requirements to drain the demisters to preclude a nonconformance with the CPS limits. This evaluation concerns the design of the plastic-film glovebag used to envelope a demister, its dripleg and drain valve for contamination control during these draining operations.

The recommended glovebag configuration is to provide a 2ft x 2ft rigid floor, plus a central criticality drain to divert any spills into a geometrically favorable vessel inside the greenhouse. Provisions are required to maintain the bag side walls perpendicular to the floor, and a flat screen or grid set an inch above the bottom floor will be needed to assure a free-flowing drain. This will accommodate the 1-gallon bottle, rag, and other equipment pieces needed within the glovebag.

2. DESCRIPTION OF DEMISTERS

There are six demister units in the 26-inch Hg vacuum system network, labeled number #1 and numbers 3 through 7. Four different demister designs have been employed, with their types designated according to the pipe size of the inlet and outlet header connections, which are either 1½-inch, 2-inch, 3-inch or 4-inch diameter. Figure 1 shows the body designs for the first three demister types, all constructed from Schedule-40, 5-inch nominal diameter stainless steel pipe. Demister unit #1 is a 1½-inch header type and is located in the east end of

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GH MASTER

2	3" DEMISTER ASSY	—
3	1 1/2" DEMISTER ASSY	—
4	MOISTURE CONTAINER ASSY	—
5	1/2" UNF-2AX 1/2 LG- STUD	ASTM-A193 304 - 2A
6	GASKET 1/2 T.N.K. 4 O.D. X 2 1/2 I.D.	TEFLON
7	1/2" UNF-2AX 1/2 LG / NUT	ASTM-A193 304 - 2A
8	2" GATE VALVE - 150"	304 SS
9	DRAIN NIPPLE / 1" SCH 40 PIPE	—
10	1" PIPE CAP, S.S.D.	ASTM-A193 304 - 2A
11	RAM DRAIN VALVE - 60" STRAIGHT NECK	304 SS
12	GASKET 1/2" SOLID 6" F.F.	TEFLON
13	GASKET 1/2" SOLID 8" F.F.	TEFLON
14	DEFLECTOR SPACER FOR 4"	—
15	SPACER FOR 4"	—
16	DEMISTER CAN FOR 4"	—
17	OUTLET 4"	SST
18	DEMISTER ELEMENT 8 1/2" O.D. X 12 LG YOREMESH SS EQU.	—
19	1/2" UNF-2AX 3/4 LG / NUT	ASTM-A193 304 - 2A
20	DEMISTER ELEMENT 8 1/2" O.D. X 6 LG YOREMESH	—
21	DEMISTER CAN FOR 3" F 2"	SST, 304
22	DEMISTER CAN FOR 1 1/2"	SST, 304
23	GASKET 1/2" SOLID 5" F.F.	TEFLON
24	DEFLECTOR SPACER FOR 3"	SST, 304
25	DEFLECTOR SPACER FOR 1 1/2"	—
26	SPACER FOR 3" F 1 1/2" F 2"	—
27	OUTLET 3"	—
28	OUTLET 1 1/2"	SST

2" SCH 40 PIPE

2"-150" S.O. FLG.

FROM
DRAWING
H-2-19755

1 1/2" SCH 40 90° L.P.
E.W. ELL (1 REQD)

③ 1 1/2" DEMISTER ASSY
SIMILAR TO ASSY #2 EXCEPT
AS NOTED

② 3" DEMISTER ASSY.

Figure 1: BODY DESIGNS FOR DEMISTERS 1 THROUGH 5

the duct level in building 234-5Z, on a header serving the vacuum circuit for the rooms of the PFP Engineering Development Laboratory. Demister #3, also in the east end of the duct level, is a 3-inch header type on the circuit from the 2nd floor. Demister #4 is also a 3-inch header type in the east end duct level, again for circuits serving the development laboratory. The 3-inch header type Demister #5 is in the duct level at the west end, on the outlet for the vacuum circuit serving the Pu-Process Support Laboratory.

Demisters number 6 and 7 are attached to 4-inch headers as the final units in the system ahead of the HEPA filters and vacuum pumps. Originally (pre 1978), the 4-inch header type demister had a body fabricated from 8-inch diameter pipe, as shown in the upper portion of the Figure 2 diagram. As this larger diameter body was not geometrically favorable, requiring extra administrative controls, the #6 and #7 demisters were changed to the flat-body design shown in Figure 3. These two units are located in Room 308 and connected in parallel upstream of the filter cylinders

The general design of a demister unit has an inlet port coming into the side of the demister section, which houses a metal mesh structure for condensing liquid vapors. Below the demister body is a "dripleg" section which collects condensate from the demister mesh. These moisture collection chambers at the bottom of the seven demisters are all of the same design, that illustrated as the 5" DRIPLEG in the lower portion of Figure 2. Included in the Leg construction is a glass sight strip to enable measuring the height of liquid accumulated in the leg. It takes 8.5 liters total liquid to fill the 25-inch tall drip-leg portion of any of the demisters.

The vertically mounted, slab tanks of demisters No 6 and 7 are 3 inches thick, 17 inches wide, 30.5 inches tall, and taper down at the bottom to a 4 inch width. Examination of the Figure 3 geometry shows the bottom of the inlet pipe about 8 inches above the bottom of the demister body. Drawing H-2-28540 shows the inlet flanges for demisters #6 and #7 attached to long 4-inch header pipes which heads downward from the units, so that the liquid level in either demister body would never be over the bottom of the inlet hole. This would give 3.5 liters maximum liquid upheld above the dripleg, for a total possible holdup of 12 liters.

For the 2"-header and 3"-header -type demister bodies shown as items (2) and (40) in Figure 1, the liquid holdup in their 5-inch casings up to the bottom of the inlet tube would be about 1.5 liters. The 1½"-header demister shown as item (3) in the figure has an upturned 1½"-diameter pipe at the inlet, which conceivably could mean full flooding to the top of the demister body (with as much as 6 liters total liquid). However, because the manifolds and piping further upstream come from facility rooms below the duct level, siphoning effects would most likely preclude such full flooding.

The outlet headers above the demister bodies include funnel valves (not shown) to permit the addition of acid solutions required in flushing operations to remove Plutonium from the demister mesh and/or to free up possible plugging of the demister leg drain valve. Inside of the demister body the inlet port is covered to prevent flush solutions from entering the inlet header.

4	MOISTURE CONTAINER ASSY		
5	$\frac{1}{2}$ "-HUNC-2AX $\frac{1}{2}$ " LG- STUD	ARM-1193 300-EX165	1" SH
6	GASKET $\frac{1}{2}$ " THK. 4.0D.X2 $\frac{1}{2}$ " I.D.	TEFLON	
7	$\frac{1}{2}$ "-HUNC-2AX2 LG /NUT HEX HD BOLT	ARM-1193 300-EX165	2" SH
8	2" GATE VALVE - 150"	304 OR 316	10% HYDRA-ACID SERVICE
9	DRAIN NIPPLE /1" SCH 40 PIPE		
10	1" PIPE CAP, SCD.	ARM-1193 (304)	
11	RAM DRAIN VALVE - 60" STRAIGHT NECK	304- SST	STREAMMAN 2" VALVE
12	GASKET $\frac{1}{2}$ " SOLID 6" F.F	TEFLON	
13	GASKET $\frac{1}{2}$ " SOLID 8" F.F	TEFLON	
14	DEFLECTOR SPACER FOR 4"		SEE DETAIL
15	SPACER FOR 4"		"
16	DEMISTER CAN FOR 4"		
17	OUTLET 4"	SST	
18	DEMISTER ELEMENT $\frac{3}{8}$ " O.D.X12 LG	YORC MESH OR EQUAL SST, ANY 400 SERIES	304 SST
19	$\frac{1}{2}$ "-HUNC-2AX3 LG /NUT HEX HD BOLT		
20	DEMISTER ELEMENT $\frac{3}{8}$ " O.D.X6 LG	304- SST OR SST, 304	
21	DEMISTER CAN FOR 3" F 2"	SST, 304	
22	DEMISTER CAN FOR 1 $\frac{1}{2}$ "	SST, 304	
23	GASKET $\frac{1}{2}$ " SOLID 5 FF	TEFLON	
24	DEFLECTOR SPACER FOR 3"	SST, 304	
25	DEFLECTOR SPACER FOR 1 $\frac{1}{2}$ "		
26	SPACER FOR 3" F 1 $\frac{1}{2}$ " F 2"		
27	OUTLET 3"		
28	OUTLET 1 $\frac{1}{2}$ "	SST	
29	GASKET $\frac{1}{2}$ " THK-2 $\frac{1}{2}$ " WIDE X18 $\frac{1}{2}$ " LG	MOROSEAL	
30	$\frac{1}{2}$ " THK GASKET -1 $\frac{1}{2}$ " SLOT, 2 $\frac{1}{2}$ " WIDE X18 $\frac{1}{2}$ " LG	RECIPRO-AC	AC 100-100
31	$\frac{1}{2}$ " THK WINDOW 2 $\frac{1}{2}$ " WIDE X18 $\frac{1}{2}$ " LG	SAFETY GLASS	SHIELD ED'S X 400TH
32	WINDOW FRAME $\frac{1}{2}$ " THK X12 LG	ANY	
33	$\frac{1}{2}$ "-20UNC-2AX1 $\frac{1}{2}$ " LG. SOC HD. SCREW	ANY	10-8 SST
34	2" STD FLAT WASHER	ANY	10-8 SST
35	$\frac{1}{2}$ " THK FLUOROTHENE SHEET - CLEAR	FLUOR	
36	2" STD. WASHER	ANY	10-8 SST
37	$\frac{1}{2}$ "-HUNC-2B HEX NUT	SST, ANY NO. SERIES	
38	DRAIN NIPPLE /1" SCH 40 PIPE	SST, 304-L

Figure 2: 4-INCH HEADER DEMISTER ASSEMBLY (ORIGINAL)

FROM
DRAWING
H-2-28535

Figure 3: FLAT BODY DEMISTER DESIGN FOR 4-INCH HEADER

3. CRITICALITY PREVENTION SPECIFICATIONS

Rev./Mod. B-0 of CPS-Z-165-80141, entitled "26-inch Hg Vacuum System" and issued December 23, 1991, governs the operation and maintenance of the 26-inch vacuum lines and components. No limits are cited in this CPS on the accumulations of plutonium along the pipelines and headers of the system. Although the straight pipes are geometrically favorable (6 inch or less diameter), the T-joints and junctions require extra considerations. For this reason, the allowed Pu accumulations in the headers of the 26"-Hg vacuum system must comply with the limits given in CPS-Z-165-80140, titled "PIPE AND ENCASEMENT SYSTEMS".

The total Pu in a demister body is limited by CPS-Z-165-80141 to 400 g, while the limit for any dripleg is 1000 g Pu. Limits are also given for containers in the vicinity; containers of 4.7 liters maximum volume and 400 g maximum Pu content are permitted with spacing rules.

The current CPS does not limit the volume of liquid in a demister leg under LIMITS FOR CRITICALITY SAFETY. However, the PROCESS CONTROLS FOR CRITICALITY SAFETY restricts the demister leg accumulation to 4.7 liters, to accommodate the maximum allowed volume of containers used for the draining of the units. It is to be noted that the procedures [REFERENCE 1] for the draining operation include steps to cover the possibility that there is more than 4.7 liters of liquid and to assure that no more than 400 g of Pu is put into any one container.

The CPS LIMITS section includes a Spacing Limits subsection, which requires 10 inches spacing between moveable containers with 15 grams or more of Pu and also from vacuum system components of 2 or more inches diameter.

4. REVIEW OF PAST EVALUATIONS

Before December of 1978 the demisters Nos. 6 and 7 in room 308 were the type shown in Figure 2, with the 8-inch diameter upper bodies. CSAR 78-013 [REFERENCE 2] was issued in mid-December of 1978 to cover the replacement of the 8-inch case types for demisters Nos. 6 and 7 with the flat-bodied, geometrically favorable design of Figure 3. This initial CSER was appended with reports on criticality calculations done for the old and new designs, including the effects of the header connections to the units. The CPS issued at that time limited the total Pu for any demister-plus-leg assemblage to 400 g and the liquid volume to 4.7 liters.

The first addendum to CSAR 78-013 [REFERENCE 3] removed the LIMIT on liquid volume in the demister on the basis that *"it is not possible to tell when the CPS allowable amount of 4.7 liters of such solution is present in a demister, therefore this limit is not auditable"*. Apparently, at the time the sight glass feature shown on the demister leg illustrated in Figure 2 was not provided, or was unreadable due to clouding.

Addendum 2 for CSAR 78-013 [REFERENCE 4] justified increasing the amount of plutonium allowed in the demister assemblages to the Limits expressed in the current CPS. The 1000 g maximum for any demister leg is based on its 5-inch diameter casing being geometrically favorable. A separate limit of 400 g was then added

for any demister body, which envelopes the demisting mesh (although the reference 4 arguments would have allowed 1000 g Pu in the demister bodies constructed from 5-inch casings).

The criticality safety evaluation supporting the pipe and casement limits of CPS-Z-165-80140 was reported in CSAR 80-016 [REFERENCE 5]. Other evaluations pertinent to the maintenance of the vacuum system are documented in CSAR 81-019 and CSAR 86-001. CSAR 81-019 [REFERENCE 6] concerned the removal and transportation of the dripleg for Demister No. 4. CSAR 86-001 [REFERENCE 7] addressed the operations for flushing out Pu from header lines of the 26"-Hg vacuum system upstream of the various demisters.

5 CRITICALITY SAFETY CONSIDERATIONS FOR GLOVE-BAG DESIGN

The demister draining involves handling of potentially-critical plutonium accumulations and liquid volumes if not confined to safe geometry containers. Spilling some of this material into the glovebag is a likely occurrence, but full loss of control which results in draining the demister into the glovebag instead of the loadout jug is considered a contingency, as an unlikely event. Given that the glovebag must envelope the demister, accommodate the glove indents to operate valves, etc., and provide for the loadout polybottle, the vertical and lateral dimensions cannot be made geometrically favorable. The bag design thus must include a criticality drain.

The review of the demister designs indicated that a demister under normal operating conditions could be holding as much as 12 liters of liquid (which would be a procedural and control noncompliance, but not a CPS limit infraction). One could postulate an error condition where the dripleg was thought to be emptied but not (because of valve plugging), and 4 liters of flush acid solution is added - - which then dissolves the plug and allows 16 liters total to drain out.

The dripleg is allowed to contain 1000 g of Pu and another 400 g is allowed in the demister body. The 400 g in the upper section, however, will be as material adhered to the demisting mesh and not available for drainout until after and if flush acid solution is added from above. In past demister draining projects, the Pu assay of the drained accumulations has been found appreciably higher than the in-situ NDA measurements of Pu holdup. On this basis, it is reasonable to assume that there could be 1500 g of Pu readily dischargeable.

A number of possibilities exist for the assumed 16 liters of liquid with 1500 g Pu to be accidentally leaked into the glovebag instead of into the L-3 container provided for loadout. There is leakage potential from faulty valve and flange seals and from mishaps in positioning the drain pipe into the L-3 polybottle. Bottle overflow from underestimation of the demister liquid holdup would spill lesser amounts, up to 12 liters with 1100 g Pu. All of these situations, however, would require serious operator inattention and disregard of procedures, unless once opened the demister drain valve sticks.

5 RECOMMENDED GLOVE-BAG DESIGN

The bag dimensions laterally will likely be on the order of up to 2 feet, considering the need for glove indents and for introducing a 1-gallon jug. The height might have to be as much as 5 ft, to accommodate the filling the jug by gravity flow below the bottom of the drip leg, and to allow introduction of flush acid at the upper end of the demister.

A glovebag design which first comes to mind is one with bag side walls which taper toward the bottom, ending up in a tube feeding a spill-drainage bottle or set to spread spills out onto the greenhouse floor (the latter arrangement being contrary to the glovebag objective for contamination control). This tapered design, however, invokes the immediate worry about plugging the criticality drain tube entrance, allowing the spillage to form a non-geometrically favorable pool of conical or pyramid shape. Dropped rags, tools, or the loadout jug could readily plug this type of bottom. Or, some other manipulation of the soft wall structure could pinch off near the outlet.

It is not practical to provide a large-area, level floor structure to retain and safely disperse potential spills (to less than ~ 275 g Pu /ft²) in a glovebag without a criticality drain. It is thus recommended that the glovebag have a rigid bottom floor of 2 ft x 2 ft dimensions, with a central drain hole, and also a screen or grid floor above the bottom to preclude drain blockage. The side walls should be kept perpendicular to the bag floor, possibly by using rigid stays for the vertical corner edges. Also, the floor should be kept reasonably level during the operations (no more than a 20 degree tilt).

The rigid floor provided could be sloped down somewhat, inward from the edges, toward the drain hole to assist drainage. An alternative would be for channels or indents in a flat floor radiating out from the drain hole. The drain hole need not be more than 2 inches in diameter, and the screen does not need to be more than an inch off the bottom at the edges. Also, the flat screen or grid should be sturdy enough to not flex much (1/4 inch) under the weight of the container and other equipment which will be set on it.

The spill-drainage container could be a standard bottle or a unit fabricated from piping of 6-inch maximum diameter. The container volume should be at least 10 liters, but on the order of 15 liters would be more appropriate. Considering the piping arrangement in the duct level, the elevation from the room floor to the bottom of the demister dripleg may not accommodate a tall drainage container. A horizontal container (lying on the greenhouse floor) is acceptable, but an air vent tube would then be required leading back into the glovebag.

6. CONTINGENCY ANALYSIS

6.1 Level Bottom Conditions

Spillage of a substantial amount of liquid from a demister leg would count as a single contingency, where a leakage path occurs but is not stopped because of an inattentive valve operator or due to a mechanical failure. The 16 liters assumed maximum liquid available in the demister plus dripleg could only flood a level, 2ft x 2ft floor 1.7 inches deep. For a slab at this depth, criticality would

require a minimum of 7 kg Pu per square ft (with full reflection), per chart # III.A.8(100)-3 in ARH-600 [REFERENCE 8]. But at most the average floor Pu loading would be 375 g/ft², so a level 4 ft² bag floor could not become critical even with a blocked drain. From the equipment descriptions presented above, it is not plausible to encounter more than 16 liters liquid, and there being more than a double batch (3000 g) of drainable Pu available as a second contingency is highly unlikely.

6.2 Bag Floor One Directional Tilting

A plausible secondary error situation would be tilting of the glovebag bottom. If we first consider only one dimensional tilting, i.e. effectively one of the horizontal bottom edges forming an axis of rotation, then a 60.96 cm (24 inch) long prismatic pool with a triangular vertical cross section is formed. The maximum width of the pool would be if its surface/floor intercept reaches the 2-inch diameter central drain hole, so that the pool's 60.96 cm long intercept edge on the floor would be 27.94 cm (11 inches) from the lowered bag bottom edge. To retain 16 liters, the bag bottom tilt angle would have to be at least 33.9°, at which angle the pool depth would be 15.59 cm (6.14 inches).

A prismatic, 61-cm long, 16 liter pool formed at 33.9° or more tilting would have a cross-sectional area of 262.5 cm². With such one directional tilting the maximum reactivity would occur with the bottom angled at 45°, because it minimizes the surface to volume ratio (and thus neutron leakage) for the fissile configuration. At this stage a 16l pool would be 16.20 cm (6.38 inches) deep.

A circular cylinder of 262.5 cm² cross-section has a diameter of 18.28 cm (7.2 inches). For the same linear fissile loading (750 g/ft), the triangular prism configuration is less reactive than the cylinder of equal cross-section area because of the prism's greater surface area. Thus, it is conservative to consider the criticality characteristics for an infinite 18.3 cm diameter cylinder as applicable for the 45°-tilted, 16 liter pool. Assuming Pu-nitrate solution (with 3% ²⁴⁰Pu, minimum) as the most plausible fissile liquid medium from the demisters, criticality for a nominally reflected cylinder requires a diameter in excess of 21 cm (8.2 inches), according to chart III.A.7.97-2 in ARH-600 [REFERENCE 8].

For the conditions of no nitration and full reflection, criticality would be possible for a 750 g Pu/ft-loaded cylinder with a diameter as low as 17.5 cm (6.9 inches), as shown by chart # III.A.7(97)-3 in ARH-600. However, for the prism geometry in question, providing full reflection on all sides and top of the pool is not feasible. Considering also the prism vs cylinder neutron leakage aspects, a critical scenario for the 16-liter pool due to one-direction tilting is not plausible. (See also reviewer's comments in Section 9).

6.3 Bag Floor Tilted to Corner

Two directional tilting, putting one bottom corner of the glovebag lower than the others, can create a deeper pool than attainable from only 1-D tilting. This would involve someone inadvertently lifting up one corner so that the glovebag floor rotates about a diagonal, sending spilled liquid to the opposite corner. A triangular pool is thus formed, with the depth determined by degree of tilt and

liquid content. At shallow angles, drainoff of much of the spill will still occur, and the pool depth will be safely limited.

With the pool right up to the drain (5.08 cm diameter), its surface edge on the floor parallel to the diagonal would be a 81.28 cm (32-inch) long line, 40.64 cm from the bottom corner and one inch from the diagonal. If the rotational angle is ϕ , the isosceles pool surface triangle would have a bisector length $B = 40.64 + \cos \phi$, and an area of $(40.64 \text{ cm})^2 + \cos \phi$. The parameter most relevant to criticality potential is the pool depth (perpendicular to surface from dropped corner), given by $H = 40.64 \times \sin \phi$. With the pool reaching the drain, its volume (for an inverted-pyramid) is $\frac{1}{3} \times \text{the base area} \times H$, giving $V = \frac{1}{3} \times H^3 \tan \phi$, or $V = 22.38 \tan \phi$ liters.

To hold 16 liters without draining, the angle thus would have to be 35.6 degrees or more. This rotation puts the Z edge at 35.7 degrees from vertical and both the X and Y edges tilting up 24.31 degrees from horizontal.

Further tilting, up to a point, would increase the reactivity for the given mass/volume loading. The most reactive tilted corner orientation (for a given volume) would be where the floor rotation about the diagonal is 54.74° , so that all three pool bottom edges are so angled from vertical (square of cosine = $1/3$). This gives the least total surface area, and thus least neutron leakage, and an equilateral triangle pool surface. With such equalized tilting, it would take 31.65 liters spilled before overflowing the drain in the glovebag.

In terms of the pool depth, the volume for the optimized, equilateral-surface corner pool is $V = \sqrt{3}/2 \times H^3$. Conversely, the pool depth attained is proportional to the cube root of the volume according to

$$H(\text{cm}) = [1.1546 \times V(\text{cm}^3)]^{1/3}$$

The surface of a 16 liter pool would be lower than the drain, with a depth of 26.44 cm (10.41 inches).

Calculations for the minimum critical Pu mass for an idealized corner-geometry solution pool have been reported by Geiger [Item # A.x in Appendix A]. A 32 g/l concentration was adopted for plutonium (3% 240) mixed with water as the most reactive (it gives minimum critical masses in spherical geometry). With nominal reflection (1 inch of water) on the top surface and 2 inches on a room floor beneath the inverted pyramid pool, a $k_{\text{effective}}$ of 1.00 was derived at a pool depth of 36.9 cm (14.5 inches) and volume of 43.4 liters. This would thus mean a minimum critical mass of 1388 g for Pu(97) in the optimum-tilt corner pool. For this glovebag evaluation such a mass is assumed available. However, as shown above, the central drain with a 2ft x 2ft floor would limit the volume to about 32 liters, and a maximum of only 16 liters liquid is expected.

The modelling of the reported calculations effectively included less than nominal reflection overall, just 1-inch water on the top face of the 4-faced configuration, and floor reflection below the apex. To put the results in perspective, the calculated critical data point for the corner pool is plotted on the Figure 4 graph of criticality data for Pu-water spheres (from ARH-600). That the corner pool critical mass and volume for a given Pu concentration (diagonal lines on

Figure 4. GLOVEBAG CORNER POOL PARAMETERS RELATIVE TO SPHERICAL CRITICALITY DATA

chart) would be greater than that for a sphere is due to the approximately 60% greater surface area for the 4-faced pyramid relative to a same-volume sphere.

Also designated on the Figure 4 chart are X and Y boundaries defining the maximum contents (16 liters volume and 1500 g Pu mass) expected to be available from the demister leg. As a sphere, 1500 g of available Pu in upwards of 16 liters liquid can be made critical, given sufficient reflection, as indicated by the overlap zone in Figure 4. The question for the tilted glovebag becomes whether or not the extra leakage due to the pyramid geometry is sufficient to raise the critical point up out of the danger zone for more reflective conditions. Given the shape of the Figure-2 curves for spheres the answer is most likely yes. However, in lieu of extensive series of calculations to demonstrate safety positively (with a k-effective not exceeding 0.935), it would be prudent to limit the achievable volume in the corner pool pyramid to the minimum for criticality as a sphere in the range of Pu mass available. A limit to 10 liters should be adequate, which translates via the above equations to a tilt angle limit of 24 degrees. (However, see calculation discussed in reviewers comments, Section 9)

7. REVISION OF CPS

The major need for revision to the CPS will be to document the design of the glovebag to be used as an engineering drawing, and to cite the drawing number in the list of equipment which can be used in drainage operations. The spacing rules of the current CPS will still apply, so it is a forgone assumption that only one gallon jug be allowed inside the glovebag. During the draining itself, there should be no more than 1 ft² of rags in the glovebag. Also, tilting of the glovebag floor should be limited to a maximum of 20 degrees.

The equipment list in the CPS should also cite the part No. for the nominal gallon jug used for the liquids to be drained from the demister. The standard jug or polybottle has a 6.00 inch outer diameter, is about 10.5 inches tall, and holds no more than 4.2 liters (1.11 gallons) if filled to the brim of the neck [REFERENCE 9]. There might need to be some revisions to the procedures to recognize that the jug fill volume is on the order of 4 liters instead of 4.7 liters.

8. CONCLUSIONS

A glovebag design is promulgated for use in demister draining operations. The essence of the design is a rigid 2 x 2 ft bottom floor with a criticality drain at the center, to feed a geometrically favorable vessel outside (within the greenhouse) should there be inadvertent spillage of the demister liquid from its intended loadout container. A sturdy screen or grid is to be set above the floor so that the required equipment inside the glovebag cannot inhibit the function of the criticality drain. This or similar glovebag configuration also could be applied in other maintenance operations on piping which potentially contains fissile-bearing liquids if the potential volume of entrained liquid is similar.

9. REVIEWER'S COMMENTS

T. Chiao of Criticality Radiological Analyses carried out the independent, technical reviews of the drafts for "CSAR 94-011, Use of Glove-bags for Demister Draining Operations", and provided the following comments.

The criticality safety evaluation was reviewed for technical adequacy of the Criticality Safety considerations for glove-bag design and design recommendations. The references and logic were confirmed to establish the intended conclusions. Some editorial comments and suggested clarifications were discussed with the author of this CSER. Additional comments are provided below.

Calculations modelling one directional tilting of the glove-bag with 1.5 Kg of Pu in 16 liters of H₂O were carried out independently by the reviewer, using tilt angles of 30° and 45°. The k_{eff} given by these calculations are 0.7023 ± 0.0042 for 30° tilting and 0.7065 ± 0.0069 for 45°. Item Nos. A.2 and A.3 in Appendix A provide details about the calculations.

A calculation was carried out also by this reviewer for the case of the bag floor tilted toward a corner, again with a loading of 1.5 Kg Pu and 16 liters H₂O. The angles of the vertical vector from the corner to the surface, which is normal to the solution surface, are 54.75 degree with respect to the bag edges. For this case the calculated k_{eff} is 0.8337 ± 0.0042

The calculational results from the reviewer support the conclusions derived in this CSER.

10. REFERENCES

Reports:

1. PFP Plant Operating Procedure Z0-170-400: "Drain and Flush Demister #4. Evelyn Baka, June 30 1994.
2. WHC-SD-SQA-CSA-20159: "CSAR 78-013, 26-Inch Hg Vacuum Systems, L. E. Thomas, December 14, 1978. SD issue date January 18, 1990
3. WHC-SD-SQA-CSA-20160: "CSAR 78-013 Addendum 1, 26-Inch Hg Vacuum Systems, L. E. Thomas, August 24, 1979. SD issue date January 18, 1990
4. WHC-SD-SQA-CSA-20337: "CSAR 78-013 Addendum 2, Demister Legs in the Plutonium Finishing Plant", S. J. Altschuler, July 25, 1991.
5. WHC-SD-SQA-CSA-20111: "CSAR 80-016, Pipe and Encasement Systems", L. E. Thomas, March 1981. SD issue date January 18, 1990
6. "CSAR 81-019; Demister No. 4 Drainage Leg, Removal and Transportation", S. J. Altschuler, June 28, 1981.
7. WHC-SD-SQA-CSA-20293: "CSAR 86-001; Flush of the 26-inch Mercury Vacuum Line, 234-5Z", W. A. Blyckert, February 19, 1986. SD issue date January 22, 1990.
8. ARH-600, "Criticality Handbook Volume II", R.D. Carter et. al., Atlantic Richland Hanford Company, May 23, 1969.
9. WHC-SD-SQA-CSA-20372: "CSER 94-006, Downloading of 10-L Containers in Glovebox 227S", A. L. Hess, August 1994. Appendix A, Item # A.8.

Drawings:

H-2-19754 26 Inch Hg vacuum system process bypass
H-2-19755 HEADER DEMISTER TRAP ASSEMBLIES WHICH HAS 4 BODY DESIGNS
H-2-19955 26 " Hg Vacuum Exhaust to 291-Z STACK
H-2-20950 26" VACUUM FILTER BOX
H-2-23733 COMPOSITE 27 INCH MERCURY VACUUM SYSTEM
H-2-27927 MOISTURE CONTAINER ASSEMBLY - - - with 5 window/plugs
H-2-28016 PROCESS ENGINEERING FLOW SCHEMATIC VACUUM AND SUMP RECEIVER SYSTEM
H-2-28087 26 INCH VACUUM SYSTEM LEAK DETECTOR INSTALLATION
H-2-28439 26" HG VACUUM SYSTEM, BLDG 291-Z FILTER AREA
H-2-28440 26"HG VACUUM SYSTEM DUCT LEVEL EAST AND WEST (2 SHEETS)
H-2-28535 4" HEADER DEMISTER ASSEMBLY
H-2-28540 LIQUID DETECTION SYSTEM, 26" HG VACUUM SYSTEM

APPENDIX A

MONK6B CALCULATIONS FOR TILTED-FLOOR POOL CONFIGURATIONS

[illegible]

<u>ITEM #</u>	<u>DESCRIPTION</u>	<u>PAGE</u>
A.1	Memo by L. Geiger on Optimum Corner Pool Criticality	16
A.2	T. Chiao Input Data, Case for Glovebag 1-D Tilting at 45°	17
A.3	SCAN Image from Case for Glovebag Floor Tilting 45°	18
A.4	T. Chiao Input, Case for Glovebag Floor Equilateral Tilting	19

ITEM A.1: MEMO BY L. GEIGER ON OPTIMUM CORNER POOL CRITICALITY

From: J L (Lee) Geiger at ~WHC83 6/1/94 1:29PM (2613 bytes: 52 ln)
To: Allen L Hess at ~WHC276
Subject: Tilted Glovebox, CORRECTION

----- Message Contents

Al,

Per your request, I have used MONK6B to determine a critical mass for a large cubical glovebox tilted on one corner, with all the fissile material collected into that corner and covered with one inch (2.54cm) of water as a nominal reflector. Additionally, the system has a two inch slab of water outside the glovebox, with the bottom surface of the slab at the same height as the lowest point in the fissile pyramid (the apex).

As a variable parameter, I chose the height of the pyramid of fissile material. The heights I chose, and the calculated k-eff for a slurry of plutonium oxide in water, 32g Pu/l slurry, 3% 240, 97% 239, are:

Height (cm)	k-eff
36.5	.9931±.0022
36.7	1.0001±.0022
36.8	.9973±.0021
36.9	.9986±.0022
37.0	1.0014±.0022
37.1	1.0030±.0021
37.3	1.0081±.0022
36.9199	.9982±.0022
36.8811	1.0016±.0021
36.9110	1.0045±.0021

These data support a critical height of approximately 36.866cm, a critical volume of approximately 43.39 l, and a critical mass of approximately 1338.5 g or 1.34 kg.

(For a pyramid with an equilateral base and perpendicular sides at the apex, the volume is $[\sqrt{3}/2] \cdot h^3$, where h is the height of the pyramid)

I have both paper and microfiche printout for the MONK runs. The microfiche printouts include two silver prints and one blue diazo print. Our records specialist has stated that microfiche is an acceptable original for records retention. Please tell me what you want (or give me the appropriate information to send the records off to storage, assuming that his material will become records.)

If you have any questions, please do not hesitate to contact me.

-Lee

```

*****
* Glovebag - - MONK5 PROBLEM FOR GLOVEBbag SLANTED 45 DEGREES
* SOUTH EDGE ON CONCRETE FLOOR, 1.5 KG TOTAL 0%240,
* IN SHAPE OF 24-IN LONG WEDGE, 24-INCHES ACROSS,
* TOTAL WEDGE SOLUTION VOLUME OF 16.0 LITERS
* BOX FLOODED VIA INLET WATER LINE FOR CONDENSOR COOLING
* GLOVEBAG DIMENSIONS 24-IN LONG, 24-IN WIDE, 66-INCHES TALL
* (1) WATER, FOR REFLECTION ABOVE SOLUTION WEDGE, AND SIDES OF BOX
* (2) 304L S.STEEL FOR SIDES OF BOX
* (3) CONCRETE
* (4) PYREX GLASS FOR TANKS, ETC
* (5) 93.75 g/l Pu in water - - 0 % 240Pu
* MATLS = H C N O NA AL SI CR FE NI
* PU239 PU240 CA
FISSION
5 13
923A 902B 259A 933C 182E 935A 25E 446C 908A 907A
9161 402C 138E
CONC .06688 0 0 .03344 0 0 0 0 0 0 0 0 0 0
CONC 0 0 0 0 0 0 .01654 .06331 .00651 0 0 0
CONC .0070232 0 0 .045396 0 .0033584 .012905 0 .0013437
0 0 0 .0026147
CONC 0 .00459 0 .04492 .00238 .00053 .01802 0 0 0 0 0
CONC .06688 0 0 .03344 0 0 0 0 0 .00023648 .00000000 0
INCHES
1
NEST 4
1 CUBOID HOLE 1 24.00 24.00 66.00 0.00 0.00 0.00
2 CUBOID 0 24.25 24.25 66.25 -0.25 -0.25 -0.50
3 CUBOID HOLE 2 28.25 28.25 66.25 -4.25 -24.25 -40.25
4 CUBOID 1 29.25 28.25 67.25 -5.25 -25.25 -40.25
PLATE 1 5
0.0 0.707107 0.707107 1 6.379 0 5
PLATE 1 3
0.0 0.707107 0.707107 2 -0.35 0 -10.35 3 0
SUPERHIST 4.0 1.4
PUNCH
-20 800 100 14 -1
POINT 12.0 3.00 3.00
END
CODE 10
HSCGONLMDX
-5.25 3.00 67.25
29.20 3.00 67.25 -5.25 3.00 -40.25
12.00 -25.25 67.25
12.00 28.25 67.25 12.00 -25.25 -40.25
END
*****

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ITEM A.2

T. CHIAO INPUT DATA, CASE FOR GLOVEBAG 1-D TILTING AT 45°

ITEM A.3:

LEGEND

WATER
CONCRETE
93.8 G PU/L
-WATER MIX

SCAN IMAGE FROM CASE FOR GLOBEBAG FLOOR TILTING 45°

TIME TAKEN = 0.0127 MINUTES

ITEM A.4

T. CHIAO INPUT, CASE FOR GLOVEBAG FLOOR EQUILATERAL TILTING

```

SYSID 1383518 34 23
SYSID 1383518 67 43
SYSID 1031305 26 45
SYSID 1383518 16 30
PASS NHFSPVNS
* Glovebag - - MONKS PROBLEM FOR GLOVEBAG X,Y,Z AXES TURNED 54.74 DEG
* ONE CONER OF BAG ON CONCRETE FLOOR, 1.5 KG TOTAL 0%240,
* TOTAL WEDGE SOLUTION VOLUME OF 16.0 LITERS
* BOX FLOODED VIA INLET WATER LINE FOR CONDENSOR COOLING
* GLOVEBAG DIMENSIONS 24-IN LONG, 24-IN WIDE, 66-INCHES TALL
* (1) WATER, FOR REFLECTION ABOVE SOLUTION WEDGE, AND SIDES OF BOX
* (2) 304L S.STEEL FOR SIDES OF BOX
* (3) CONCRETE
* (4) PYREX GLASS FOR TANKS, ETC
* (5) 93.75 g/l Pu in water - - 0 % 240Pu
* MATLS = H C N O NA AL SI CR FE NI
* PU239 PU240 CA
FISSION
5 13
923A 902B 259A 933C 182E 935A 25E 446C 908A 907A
9161 402C 138E
CONC .06688 0 0 .03344 0 0 0 0 0 0 0 0 0
CONC 0 0 0 0 0 0 .01654 .06331 .00651 0 0 0
CONC .0070232 0 0 .045396 0 .0033584 .012905 0 .0013437
0 0 0 .0026147
CONC 0 .00459 0 .04492 .00238 .00053 .01802 0 0 0 0 0
CONC .06688 0 0 .03344 0 0 0 0 0 .00023648 .00000000 0
INCHES
1
NEST 4
1 CUBOID HOLE 1 24.00 24.00 66.00 0.00 0.00 0.00
2 CUBOID 0 24.25 24.25 66.25 -0.25 -0.25 -0.50
3 CUBOID HOLE 2 28.25 28.25 66.25 -4.25 -24.25 -40.25
4 CUBOID 1 29.25 28.25 67.25 -5.25 -25.25 -40.25
PLATE 1 5
0.577288 0.577288 0.577288 1 10.41 0 5
PLATE 1 3
0.5772880 0.577288 0.577288 2 -0.35 0 -10.35 3 0
SUPERHIST 4.0 1.4
PUNCH
-20 800 100 14 -1
POINT 12.0 3.00 3.00
END
CODE 10
HSCGONLMDX
-5.25 3.00 67.25
29.20 3.00 67.25 -5.25 3.00 -40.25
12.00 -25.25 67.25
12.00 28.25 67.25 12.00 -25.25 -40.25
END

```