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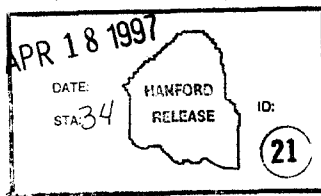
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Abstract: This document provides a readily available source of technical reports for the development of the safety documentation provided for the waste retrieval sluicing system (WRSS), designed to remove the radioactive and chemical sludge from tank 241-C-106, and transport that material to double-shell tank 241-AV-102 via a new, temporary, shielded, encased transfer line.

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1.0 PURPOSE

The purpose of this document is to provide a readily available source of the technical reports needed for the development of the safety documentation provided for the waste retrieval sluicing system (WRSS), designed to remove the radioactive and chemical sludge from tank 241-C-106, and transport that material to double-shell tank 241-AY-102 via a new, temporary, shielded, encased transfer line.

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Los Alamos

Stephen F. Agnew
Group CST-14, Mail Stop J586
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Los Alamos, New Mexico 87545

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To: Charlie O'Dell, DOE-EM32

Copies to: Harold Sullivan, TSA-11
Harry Babad, WHC
Oliver Wang, WHC

Dear Charia:

As per your request, I have reviewed the information that you faxed me on the thermal problems with C-106 and here are my thoughts and analysis.

Criticality is definitely not an issue. Not only are the Pu levels well below any level of concern, the very large amount of iron (a neutron poison) in the sludge (1-2 mol/L) absolutely precludes any criticality within the sludge. The measured levels of Pu in a composite of the sludge are 3.1 $\mu\text{Ci/g}$, and the historical estimates for any layer within the tank are in the range 0.7 to 6.0 $\mu\text{Ci/g}$. Criticality would occur in an infinite volume of pure water at about 250 $\mu\text{Ci/g}$ Pu, but there would have to be much higher concentrations when neutron poisons, such as iron, are present. Therefore, this is a very large non-issue.

To say the least, it was not a good idea to let this tank dry out. Steam expansion from sludge hot spots has been a traditional problem at Hanford in the past, (i. e. tank bumping) and we will be dealing more with this problem in the future with other tanks. This tank's problem started when it unexpectedly began to boil in 1971. Much work was performed to get the boiling under control, which it has been until now. The second to-tree r14 was put into the tank in order to better determine the sludge temperatures for this tank.

Historically, there has always been a discrepancy between the two thermocouple trees in tank C-106, to-tree r8 and to-tree r14. The mystery has been that the tree that was placed into riser 14 in 1977 always showed colder waste temperatures than the original tree in riser 8, although the dome space temperatures between the trees agreed quite well.

Although there have been many different explanations for this anomaly, it now appears that the chimney hypothesis¹ has now been proven. This hypothesis was that there was the sludged pit or hole dug that was dug into the sludge layer in 1977 when the tree was originally inserted persisted even after installation. This hole or "chimney" allowed to-tree r14 to cool by convection of the liquid around it, even though the bulk waste in the vicinity was always at much higher temperatures. The final test of this hypothesis would have been to close up the chimney somehow and watch the temperature rise for to-tree r14. I suggest that this is exactly what has now happened in C-106.

The scenario goes something like this. Evaporation of all cooling water removed significant conduction and convection paths for cooling the upper sludge, thereby allowing upper portions of the sludge to dry out. Once the sludge had dried

¹Agnew, S.F. "Analysis of the History of 241-C Farm." LAUR-93-3605, October 1993, p. 33-5.

out, a hot spot develops and becomes a substantial steam source, much like now exists under tank A-105. This steam source drives steam into the surrounding waste, causing the waste to heave and flow thereby sealing up the fissures that have developed over the past—including the chimney around to-tree #14.

Once the fissures are sealed up, only pure conduction paths can cool that "hot spot", and the hot spot will heat to its conduction limit. (We can estimate the size of the hot spot by knowing the exact details of the experiment.) At any rate, water addition into the dried hot spot will eventually open up new fissures and cool the hot spot to below the boiling point. However, during this period, there will be steam surges as the water trickles back into the hot spot, which I believe is responsible for the level fluctuations that are now occurring. This effect is much akin to the geysers that occur in the earth's mantle.

The good news is that to-tree #14 is now "packed" into the sludge and we will finally be getting realistic temperatures for the tank center for C-106. The bad news is that it might take some months for this tank to settle down. Last time C-106 was boiling, remember, it took about a year and a half for it to "settle down". But it was a lot hotter back then.

Attached find an thermal analysis (that is completely unofficial and my own) for the dome space temperature of C-106 under various scenarios. Please take these estimates with a very large grain of salt, but they are based on a tank heat load of 88,000 Btu/hr, my best estimate based on the dome temperature and the evaporation rate. If I remove the evaporative heat loss but keep ventilation, I predict the dome space temperature would increase from around 90°F to 145°F, or about a 65°F rise in dome space temperature. The waste temperature, on the other hand, will go up at least that amount, and probably much more. If it went up by the same amount, it would increase from 160°F to 225°F. Of course, once the waste went above 212°F it would dry out and the temperature would in fact increase even more, since water channels would be replaced by steam and gas.

In closing, I suggest that there are other tanks of similar concern for steam problems with future water additions, and we should look carefully at these tanks before adding water. They include A-105, C-104, and a series of tanks in SX farm.

Suggested action: Believe to-tree #14 readings—there is nothing wrong with that tree! It has been accurate all along. A better thing to do than verify that tree would be to test the waste temperature in a completely different spot, for example the other side of the tank, in risers 1, 2, 3, 4, 10, or 11. That would tell us more about the waste temperature.

The steam surging phenomenon should settle down after a few months, as fissures open and allow water convection cooling. Until then, we have little to do. If the tank penetrometer were operating, we could start punching holes in the waste to facilitate the process, but that device is not yet operating. (Another push for an in-tank penetrometer, pardon the pun.)

Sincerely,

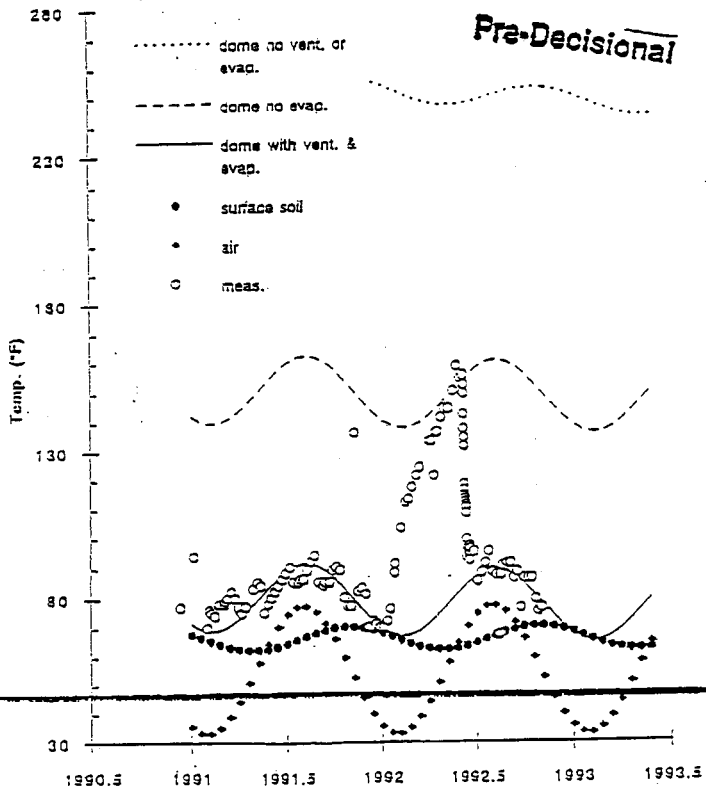


Steve Agnew

cc: CIC-DO, CST-14

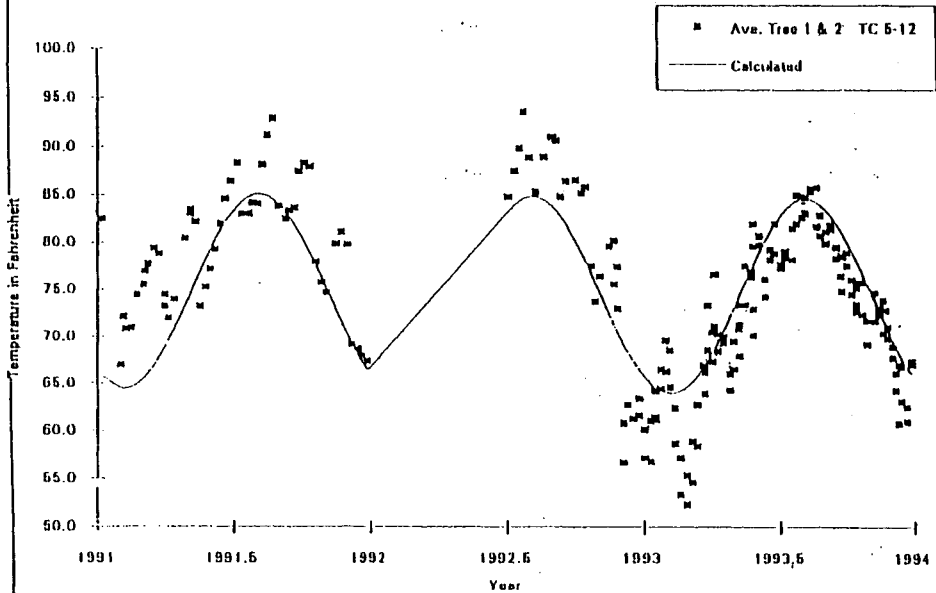
trial thermal model Chart 1

Tank C-106 Thermal Mode



Pre-Decisional

C-106 Dome Space Temperature



Title: Analysis of the History of 241-C Farm

Author: Stephen F. Agnew

Submitted to: as Technical Report to DOE HQ EM-36

Date: October 1993

around 125°F for tc1 and tc2 as compared to 110°F for tc1 and tc2 for C-105, and the average dome space temperature is 108°F for C-103, while it is only 74°F for C-105. These measurements are consistent with the moderate heat load for C-105, as shown in Tables 1 and 2, and the fact that it is somewhat ventilated by connections to C-106.

The plutonium assay was reported as 0.85 $\mu\text{Ci/g}$, which suggests a Pu inventory of 2,532 Ci or 12.5 kg. This is about a factor of two lower than I predict based on the layers of waste type shown in Table 7. I have no explanation for this difference.

C-106

Solids layering

Tank C-106 received 532 kgal of MW in '47-3 as cascade from C-105, was sluiced in 1953, and there is apparently little heel left from this operation (see Fig. 10). Thereupon, C-106 received 538 kgal UR in '54-3, 420 kgal CWP '58-2 to '60-2, 854 kgal from AR-002 '70-1 to '70-4, and 2,892 kgal 8L from '74-3 to '76-1. The sludge accumulation should have been according to that shown in the Table 8.

Table 8.
Estimates of Solids for C-106.

date	q	meas. solids	solids gain/loss	pred. layer	layer type	primary waste volume	comments
1953	2		0	0	MW/cas.	532	
1954	3		27	27	UR	538	
1957	4	29	2	2	meas.		gain from ??
1960	2		34		CWP	420	
??			-6	29	CWP		loss to ??
1969	4	57			meas.		
1970	4		93		AR-002	854	
1971	1		-24	59	AR-002		loss to C-103
1975	2		71	71	8L	2892	2.5 vol%
1985	2	197			meas.		

The solids layering in C-106 would then be 29 kgal UR, 28 kgal CWP, 69 kgal AR-002 solids, 71 kgal 8L, and 32 kgal of supernatant (which varies since water is added periodically to replace that lost by evaporation).

The only unrecorded loss of solids is the 24 kgal of AR-002 solids lost to C-103 in 71-1. These high strontium solids (termed AR-002) are actually P solids (sludge from Purex waste) that were being washed in AR-002, a tank in AR vault. The solids mostly originated from A-106, which was a primary receiver for P waste from '60-4 to '63-1, although A-106 accumulated solids from A-104 as well. Approximately 184 kgal of solids were sluiced from A-106

starting in Feb. 1970 through Jun. 1972, with 93 kgal of those solids ending up in C-106.

Radionuclide inventory estimate

Based on the solids layering and the core composite information,⁴⁷ the strontium concentration in the core composite is 2.8 CVL, which would be 8.0 CVL if it were all concentrated in the 69 kgal AR solids layer. A previous report by Walker⁴⁸ derives much larger inventories of Sr-90 in C-106. This author uses a sludge analysis⁴⁹ that is 18.8 CVL Sr-90, and a total sludge volume of 140 kgal, and states that the total Sr-90 is then 5-10 MCi. However, this author does not differentiate between BL and AR-002 sludges. The former has very little Sr-90, while the latter has Sr-90 on the order of 8.0 CVL. Thus, Walker derives a much larger total Sr-90 than I do, but I believe that his strontium concentrations were not representative of this waste type—Walker did not take into account the absence of Sr-90 in BL waste. My estimates for Sr-90 are tied to a tank core analysis as opposed to some grab sample, and are consistent with the waste type.

The reported dose readings on the core segments as they are brought to the surface are unusually high for the top two segments considering the low radio nuclide content expected for BL (B-Plant low-level) waste. These dose measurements are not consistent with low radio nuclide contents and I can't explain the discrepancy.

The plutonium concentration for C-106 from the core analysis was 3.1 $\mu\text{Ci/g}$, which leads to an inventory of 53.1 kg. My estimation of the plutonium content of the tank is 63.7 kg, which is comparable to that estimated from the analysis.

Temperature anomaly in C-106

The inadvertent addition of high strontium sludge to C-106 in 1970 has been noted before in several reports.^{50,51,52} Temperatures in excess of boiling occurred shortly after the addition of the high Sr sludge. In 1978, a second thermocouple tree was installed in riser 14 of C-106 (see Fig. 1) to help monitor the temperature of this tank. The temperature readings from thermocouples at the same level between the two trees agree within the dome space, but have never agreed within the waste, and there are differences on the order of 35-45°F between the tc2's of each tree. For example, in January 1993, tc1-r8 (thermocouple 1, riser 8) was 153°F, while tc1-r14 was 119°F. Likewise, the

⁴⁷Weiss, R. L. "Data Transmittal Package for 241-C-106 Waste Tank Characterization," SD-RE-TI-205, January 1988.

⁴⁸Ibid Walker.

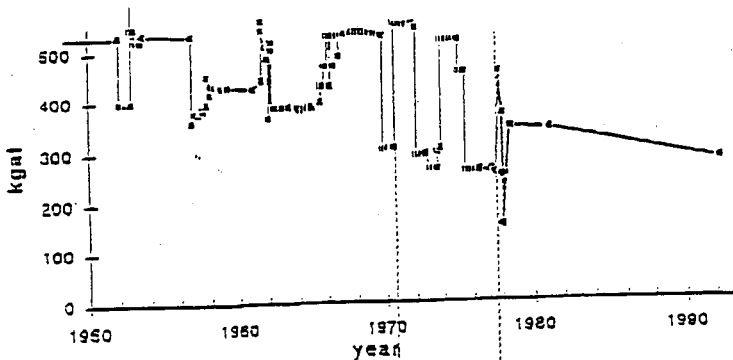
⁴⁹Horton, J. E. "Analysis and Characterization of Sludge Sample from TK-106-C," letter to O. R. Rasmussen, Jan. 3, 1975.

⁵⁰Ibid Walker.

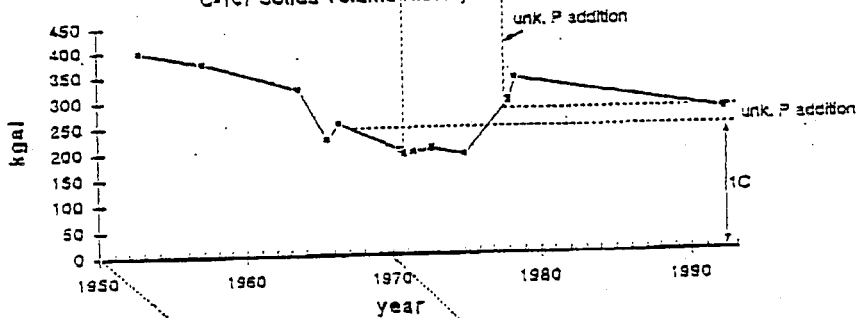
⁵¹Ibid Bacad, H. 1992

⁵²Fulton, J.C. "Tank 241-C-106 Thermocouple Tree Data Comparisons," 93S2648, letter to R. E. Gerton, April 1, 1993.

C-107 Volume History



C-107 Solids Volume History



C-107 Waste Types

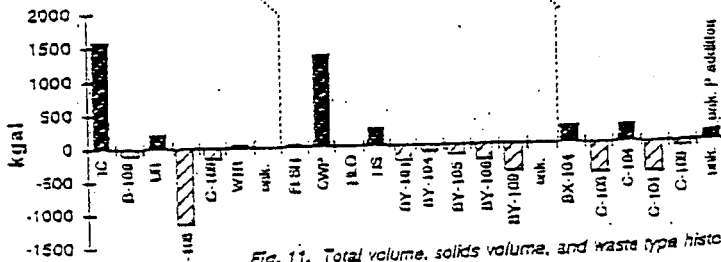


Fig. 11. Total volume, solids volume, and waste type histories for C-107.

1c2's were at 131 and 87°F, respectively. Riser 9 and Riser 14 are about 30' apart, and it seems counter-intuitive to have the higher temperature on the outside of the tank waste. In other words, I would expect the temperature near the tank outer wall to be lower at the same level as compared to the temperature of the waste near the center of the tank.

I suggest that this explanation for this anomaly is a chimney effect. That is, the riser-14 tree was likely inserted with a water lancing operation that effectively drilled a hole or chimney within the waste sludge. If this sludge chimney did not collapse following the insertion of the thermocouple tree, it would allow the free convection of liquid within that chimney and therefore the cooling of the waste around the tree. This localized convection would produce a cold spot that would not be representative of the temperature of the sludge. In all likelihood, then, the actual peak sludge temperatures at the center of the tank are actually higher than either thermocouple tree is now measuring.

An experiment to test this chimney hypothesis would be very simple and involve tamping the sludge around the tree in riser 14 in order to collapse the sludge around the tree. It is very important to have an accurate representation of the temperature of the sludge in C-106 and that will only be possible if the tree is packed into the sludge so as not to allow any free convection around the tree.

Another hypothesis that has been suggested is the presence of a "doughnut" of strontium sludge around the outer wall of the tank, concentrating the heat source near the wall.

C-107

Tank C-107 received 1C (first cycle decontamination) waste from the BiPO_4 process, which was a mixture of the actual waste from this cycle and the decaying waste (see Fig. 11). 1C waste had the highest solids fraction of any waste stream at Hanford, being on average 25 vol% solids.

Table 9.
Estimates of Solids for C-107.

date	q	meas. solids	solids gain/loss	pred. layer	layer type	primary waste volume	comments
1948	3		395		1C	1,588	24.3 vol%
??			4		unk. gain		
1952	3	399			meas.		
1953	3		11		UR	211	
1962	2		109		GWP	1,364	
1963	2	321	-198		meas.		loss to ??
??			-72	243	1C		unk. loss
1977	2	249			meas.		
1977	3		29		Sr solids		reported in Walty
1992	1	275	-3	26	Sr solids		unk. loss

Los Alamos

HNF-SD-WM-RPT-293 REV 0

Stephen F. Agnew
Group CST-14, Mail Stop 0586
Los Alamos National Laboratory
Los Alamos, New Mexico 87545

DATE: 23 July 1994
IN REPLY REFER TO: CST-14-94-sta208a
FAX: (505)667-3651
BITNET: 039409@LANL.gov
TELEPHONE: (505)665-1764

To: Charlie O'Dell, DOE-EM32

Copies to: Harold Sullivan, TSA-11
Harry Babad, WHC
Oliver Wang, WHC

Dear Charlie:

I met with Oliver Wang and his team on 26 July 1994 at Hanford and discussed at some length the issues surrounding the C-106 heatup that followed the process experiment that was performed in April-June 1994.

It is clear that we do not yet have a full understanding of the structure of the sludge layer in C-106, and therefore we do not understand all of the mechanisms by which the sludge cooled. The previous model or paradigm for the sludge cooling has been a pure conduction model for cooling the lower sludge layers. It is apparent now, however, that a second mechanism, perhaps the more important mechanism, was one in which "fumaroles" or convection chimneys that had previously formed in the sludge provided convection channels by which the lower sludge layer could cool by convecting hot fluids to the surface layer. In this model, the upper sludge layer would be a "Swiss cheese" of fumaroles ranging in size from 2-10 feet in diameter. Any changes in the configuration of this layer, as undoubtedly occurred during the experiment, could close some of these fumaroles, perhaps permanently.

It is clear that there are two primary concerns associated with C-106 at this time. First, the continued heatup of the lower level of the tank, as indicated by tcf of to-free r14, has averaged around 1°F per day for the last ten days. It is now at 210°F and is showing no sign of stabilizing. The boiling point of pure water at that level in the tank is around 222°F (105°C), but the salt content should raise it to around 230°F or so. I expect steam production at the lower layer of the tank once this temperature is reached, which would result in swelling of the lower layer and some kind of venting or eruption of the lower sludge layer. Thus, I expect something to happen in twelve to twenty days. Of course, we may not be measuring the hottest part of the tank at riser 14, but until there is significant level increase and/or fluctuations, the level data would suggest that the layer is not yet boiling.

The second issue is the apparent change in the structure of the sludge that is trapping more heat in the lower sludge layer. This heat trapping is indicated by a marked reduction in the evaporation rate of surface water, and is evidently the cause for the temperature rise. Apparently, the tank level has not changed at all since the last water addition on July 3rd. This is very distressing since the previous tank cooling rate involved a 2.2" loss of surface water per month, which would suggest a 1.2" loss should have occurred by July 19th. Since this water evaporation accounted for about 70,000 Btu/hr heat removal from the tank, its loss means that the heat is going somewhere else, i.e. it is heating up the sludge above traditional levels to some new value. Until the tank's behavior becomes steady, that

new value could exceed the boiling point of the tank liquid at _____ level in the waste and some kind of steam driven eruption is likely.

This eruption could range all the way from a "glug-glug" localized event to some more deleterious global tank "bump." At this point, it is very difficult to predict which of the two extremes will occur. I suggest based on past history that a "glug-glug" event is most likely, but I can not rule out a more substantial tank bump.

All of these notions are limited by the fact that we do not have enough analysis of bounding conditions for the heat source distribution, there is no tank level behavior on an hour by hour basis before, during, and after this process experiment, or any model of convective driven "fumarole" sludge cooling.

Recommendations:

1) Start immediate plans to cool tank. This could involve an air conditioner, added ice directly to tank, or some other heat exchange process. We need to get that tank back to a heat removal rate of about 50-70,000 Btu/hr as soon as possible. We will not be out of the woods with this tank until we can show that the heat losses with ventilation are back to the previous levels.

2) Immediately start taking level data, at least once per hour, preferably at least four data points for each periodic change that is noted. For example, if there is a fifteen minute variation in level, then we need data every six minutes. Accumulate level information from before the experiment up until the present time and into the foreseeable future. I can't overemphasize how important it is to have as much information as possible for this tank over the next few months.

Level data will show us if there is any steam vapor accumulation, tank level changes due to thermal expansion of the waste will bound the size of the hot spot, and geyser behavior due to periodic steam venting should provide some indication of how unstable that tank waste is becoming.

3) The immediate hazard is not high temperatures *per se* but rather tank bumping due to steam vapor production and venting. We need immediate help from the boiling waste "gray beards" for this problem. There is a history of this problem at Hanford and we should tie into that expertise.

4) Start an intensive effort on analysis of the behavior of C-106. We need better bounding estimates of tank behavior, including localization of heat source into a layer that is consistent with historical fill records, Sr-90 concentrations in the sludge layer as high as 20 Ci/L, with total inventories in the range 5-6 MCi (1 MCi = 1e5 Ci), better understanding of seasonal evaporation rates and seasonal behavior of level and temperature, more psychrometric data on the outlet vapors, continuous measured pressure of the tank dome space and ventilation rate, and any other data that we can get our hands on.

Sincerely,



Steve Agnew

cc: CIC-DO, CST-14

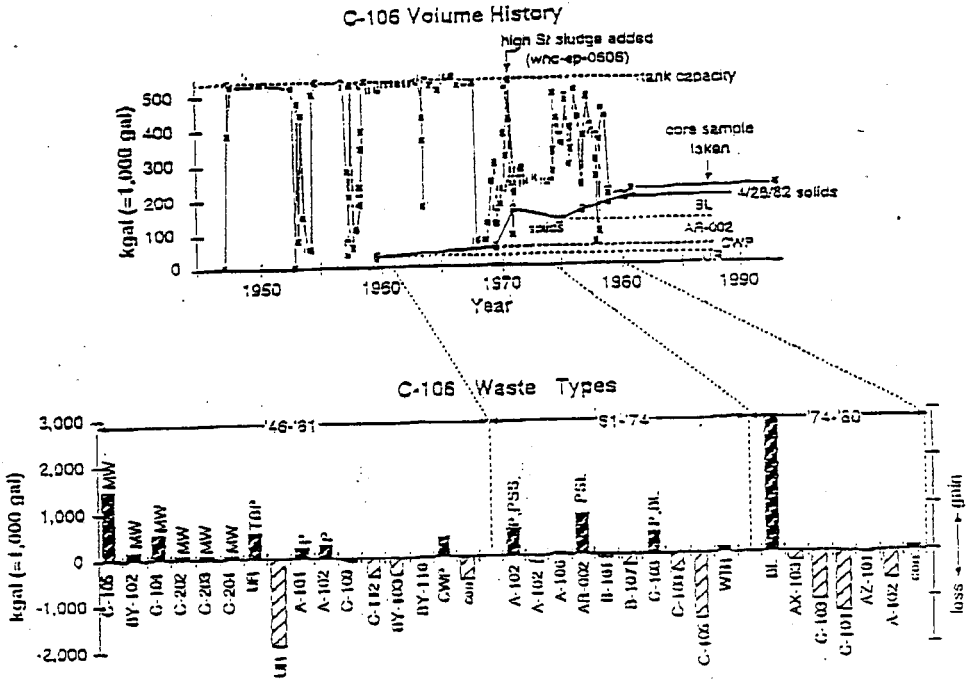


Fig. 9. Total volume, solids volume, and waste type histories for C-106.

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**Westinghouse
Hanford Company**
**Internal
Memo**

From: Safety Fluid Mechanics 74220-95-SWC-001
 Phone: 376-0438 HO-34
 Date: August 28, 1995
 Subject: GOTHIC MODEL FOR TANKS C-104, C-105, AND C-106 TO EVALUATE
 HYDROGEN GAS CONCENTRATION DATA

To: D. M. Ogden HO-34
 cc: R. J. Cash S7-15
 J. C. Conner H4-68
 J. P. Harris, III S2-48
 J. D. Hopkins R2-11
 G. D. Johnson S7-15
 SWC File/LB

An evaluation of flammable gas concentrations in C Farm has been performed.

A GOTHIC model has been constructed for tanks C-104, C-105, and C-106 to evaluate hydrogen gas concentration data for those tanks. A schematic of the model is shown in Figure 1.

Volumes 1, 2, and 3 represent tanks C-105, C-104, and C-106, respectively. Each tank volume contains a thermal conductor to maintain internal tank temperatures at measured levels. Ventilation system ducts are modeled by volume 4 and flow paths 1, 2, and 6. Pressure boundary 3P represents the ventilation outlet. Inlet risers are modeled by flow paths 3, 4, and 8, which are also attached to pressure boundary conditions. Underground cascade lines are represented by flow paths 5 and 7. A hydrogen source is introduced into each tank by flow boundaries 5F, 6F, and 7F through flow paths 9, 10, and 11.

The model was calibrated by setting the inlet pressure boundary conditions to atmospheric pressure and adjusting the inlet riser loss coefficients and the outlet pressure until internal flows and pressures matched measurements taken during ventilation system flow balancing operations. After the flow balancing calibration was complete, the hydrogen source rates were adjusted to try to match measured hydrogen concentrations for each of the tanks.

Table 1 shows a comparison of GOTHIC model results and measured data for each of the three tanks. The GOTHIC results were obtained with a hydrogen source rate of 0.0000005 lbm/s in each tank. This comparison suggests that the hydrogen concentration levels measured in

tanks C-104, C-105, and C-106 are consistent with approximately equal hydrogen generation rates in all three tanks and are consistent with the measured and predicted tank ventilation flows.

Table 1. Hydrogen Concentration Comparison for C-104, 105, and 106.

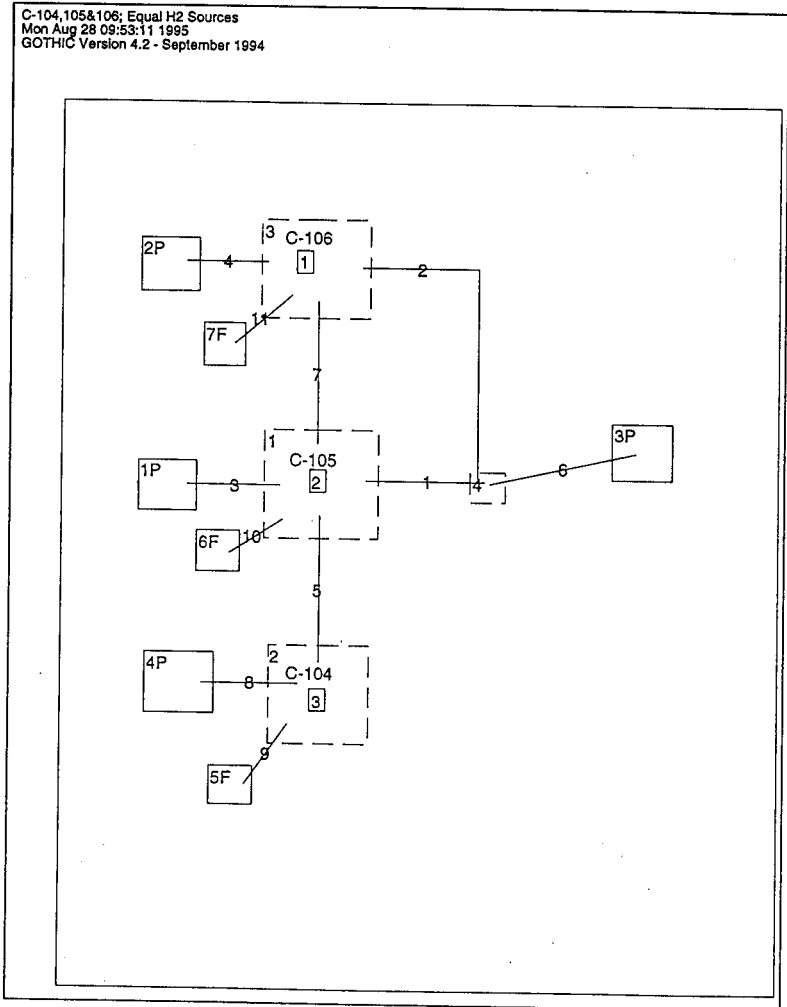
Tank	Measurement (ppm)	GOTHIC model (ppm)
C-104	68	69
C-105	22	24
C-106	10	13

S. W. Claybrook
S. W. Claybrook
Consultant

bab

Attachment

Figure 1. GOTHIC Model for C-104, C-105, and C-106.



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**Westinghouse
Hanford Company**

**Internal
Memo**

From: Projects SAR Engineering JCC-8M200-005A
 Phone: 376-2058
 Date: August 17, 1995
 Subject: OFFICIAL PROJECT FILES RECORD OF REVISION TO WHC-SD-WM-SEL-033,
 REV 1, INTERIM SAFETY EQUIPMENT LIST FOR 241-C-106 WASTE
 RETRIEVAL, PROJECT W-320: COVER BLOCKS SUPPLIED BY PROJECT W-320

To: J. W. Bailey S6-12
 J. P. Harris III S2-48
 K. W. Leliefeld S2-48

cc: F. W. Bradshaw S2-47 J. J. Huston S6-12
 R. W. Davidson S2-47 L. E. Johnson H4-68
 D. L. Evans S2-47 Official Project Files R1-28
 K. B. Ferlan S2-48 [REDACTED]

- References: 1) Internal Memo, J. C. Conner to J. W. Bailey, et al.,
 "Official Project Files Record of Revision to
 WHC-SD-WM-SEL-033, Rev 1, Interim Safety Equipment List for
 241-C-106 Waste Retrieval, Project W-320: Cover Blocks
 Supplied By Project W-320
- 2) Internal Memo, J. C. Conner to J. W. Bailey, et al.,
 "Official Project Files Record of Revision to
 WHC-SD-WM-SEL-033, Rev 1, Interim Safety Equipment List for
 241-C-106 Waste Retrieval, Project W-320
- 3) WHC-CM-4-46, Safety Analysis Manual, Section 9, Table 1,
 Revision 1, "Safety Classification Criteria and Components,"
 Dated May 17, 1995
- 4) WHC-CM-4-3, Volume 1, Industrial Safety Manual, Section G-1,
 Revision 3, Change 1, "Operations Lock and Tag Program,"
 Dated April 28, 1995
- 5) WHC-SD-WM-OSR-005, Single-Shell Rank Interim Operational
 Safety Requirements, Section 3.6.1 Revision 0-A, "Transfer
 System Cover," Dated April 3, 1995
- 6) WHC-SD-WM-SEL-033, Interim Safety Equipment List (SEL) for
 241-C-106 Waste Retrieval, Revision 1, Dated November 15,
 1994
- 7) WHC-SD-WM-SEL-020, Aging Waste Facility Interim Safety
 Equipment List (SEL), Revision 2, Dated June 9, 1993
- 8) WHC-SD-PSE-010, Preliminary Safety Evaluation (PSE) for
 241-C-106 Waste Retrieval, Revision 2, Dated October 19, 1994

J. W. Bailey
Page 2
August 17, 1995

JCC-8M200-005A

This revision represents slight editorial changes and clarification of the evaluation of the Waste Retrieval Sluicing System design and the EDE dose consequences caused by a postulated break of both supply and return transfer lines during a seismic event. This memo supersedes Internal Memo number JCC-8M200-004 dated August 16, 1995 (Reference 2).

Interim Safety Equipment List Safety (SEL) for 241-C-106 Waste Retrieval, (Reference 5), has been produced in support of the Preliminary Safety Evaluation (PSE) for 241-C-106 Waste Retrieval, (Reference 7), for Project W-320. The Interim Safety Equipment List (Reference 5) is presently being revised to reflect further progress made in the design of Project W-320 and subsequent safety analyses of this design. This memo serves as the official project file record of an additional revision made to the Interim Safety Equipment List (Reference 5) and supersedes Internal Memo number JCC-8M200-004 dated August 8, 1995 (Reference 2).

In the Interim Safety Equipment List (Reference 5), the waste transfer pits for AY-102 have been classified as Safety Class (SC)-1 according to the Aging Waste Facility Interim Safety Equipment List (SEL), (Reference 6). The pit/box structure (cover block) performs SC-1 functions based on the analysis in Reference 6. The safety function of the pit/box structure is to contain any spill and confine resulting aerosols. If the cover block is properly installed, the pit/box will perform its safety function.

During waste transfer or recirculation of liquid waste within C-106 pits, a spray leak scenario could be postulated that would lead to SC-1 consequences. Such an accident scenario could consist of the following events:

- a. An initiating event where a spray leak occurs in a pit due to failure of jumpers, connection or flange
- b. A single failure where a pit cover block is left off
- c. The spray is oriented such that it sprays out of the opening in the pit
- d. The leak detectors may not activate because of most of the spray is out of the pit, and also, not enough liquid is lost that could be detected by material balance discrepancy (MBD) analysis.

Calculations were performed for the above scenario, and the resulting offsite Effective Dose Equivalent (EDE) value for a connector failure, with the pit cover block off, exceeds the risk acceptance guideline and is unacceptable.

J. W. Bailey
Page 3
August 17, 1995

JCC-8M200-005A

Based on evaluation of the Waste Retrieval Sluicing System design and the EDE dose consequences caused by a postulated break of both supply and return transfer lines during a seismic event, redundant seismic switches will be installed to shut down the sluicing transfer system. With the operation of the seismic switches and a postulated release of waste for approximately 10 seconds (the seismic switches will terminate operation of the pumps, and the liquid release to the environment will stop within 10 seconds allowing for pump coast down), the calculated EDE offsite and onsite dose consequence values are reduced to $1.0E-3$ mSv and $1.0E-3$ Sv, respectively. A connector break inside the pit with the cover block on, with all openings closed, and a release time of 8 hours, the offsite EDE dose value of $3.8E-6$ mSv is well within the allowable limit of 5 mSv, and the onsite dose value of $3.6E-6$ Sv is well within the allowable limit of 50 Sv based on Section 9 of WHC-CM-4-46 (Reference 2). Therefore, if the pit covers are installed before any transfer operation via the jumpers/connectors within the pit, there is no impact to health and safety of personnel or to the environment. The pit covers are required to be installed and remain in place while performing the transfer per Section 3.6.1 of the Single-Shell Rank Interim Operational Safety Requirements (Reference 4). In addition, Reference 3, WHC-CM-4-3, Industrial Safety Manual Section G-1, Revision 3, Change 1, "Operations Lock and Tag Program" will be implemented to ensure safety of the personnel and the environment.

The seismic switches have been classified as SC-1 per the safety function they perform and WHC-CM-4-46, Criterion 2 of Table 1, Section 9, (Reference 2). The standalone seismic switch enclosures are located outside the C-106 and AY-102 facilities, and have two independent compartments housings for each of the redundant switches. A barrier wall is provided between the two compartments, designed for missile protection in accordance with the SC-1 requirements of Hanford Plant Standards SC 4.1.

The safety function of the cover blocks to be provided by Project W-320 is to confine any spill and resulting aerosols, which are evaluated to have SC-3 consequences if the cover blocks are properly installed, and based on the safety function that the seismic switches perform. Therefore, the cover blocks to be provided by Project W-320 will perform a safety class three function and are classified as a SC-3.

If you have any further questions please call me at 376-2058.



J. C. Conner, Principal Scientist
Project SAR Engineering

jwh

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**Westinghouse
Hanford Company**
**Internal
Memo**

From: TWRS Safety Engineering 8M110-JCC-95002
 Phone: 376-2058 H4-61
 Date: February 6, 1995
 Subject: SOURCE TERM FOR SAFETY ANALYSIS SUPPORT OF THE WASTE RETRIEVAL OF
 TANK 241-C-106

To: J. W. Bailey S6-12
 J. P. Harris III S6-12
 D. J. Shrimpton S3-10
 Official Field File S6-12
 Official Project Files RI-28

cc: C. A. Augustine S6-12
 K. D. Gibson H4-61
 JCC LB/File

The initial sample data used to develop the radiological and toxicological unit doses in support of the safety documentation for the waste retrieval of Tank 241-C-106 was obtained from WHC-SD-WM-TI-565, Radionuclide and Chemical Inventories For the Single Shell Tanks (SSTs). This document lists the highest concentrations of radionuclide and chemicals found in a survey conducted by WASTREN of sample data maintained by Tank Waste Remediation System (TWRS) engineers and by the Westinghouse Hanford Company (WHC) Tank Characterization program. The reported analyses were, in general, from the most recent waste tank samples up to approximately 1990. This data was believed to give a reasonable indication of the radionuclide and chemical concentrations for use in safety analysis. This data does not represent the entire universe of sample data available at Hanford.

The data for this document was collected, entered into a data base, and plots were prepared by Kaiser Engineers Hanford (ICF KEH). Sample or calculated results were obtained from:

1. WHC-SD-WM-TI-565, Radionuclide and Chemical Inventories For the Single Shell Tanks (SSTs).
2. The Tank Sample Analysis Data Base prepared by Westinghouse Hanford Company's (WHC) Risk Assessment Technology group (Braun Database).
3. The files of sample data collected by the Tank Characterization Program.
4. Tank Characterization Reports (TCRs).
5. The Tank Characterization Database (TCD) maintained by Pacific Northwest Laboratories for WHC.

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8M110-JCC-95002

6. The Track Radioactive Components (TRAC) database. This document does not contain actual sample results but gives calculated concentrations of radionuclides derived from production records and waste process flowsheets.
7. WHC-SD-WM-TI-628, Estimated Chemical and Radiochemical Inventories Spreadsheet: NE Quadrant, A, AX, B, BX, C Farms. This document does not contain actual sample results. It gives calculated concentrations of radionuclides and chemicals derived from process flowsheets and historical data on transfers in and out of the Hanford tanks.

Eleven radionuclides and 25 chemicals were identified for review using the scatter plots. For radionuclides, the 11 radionuclides were plotted for C-106, in both the liquid and solid phases. For the chemicals, the 25 chemicals were plotted in both the liquid and solid phases.

On each plot, a concentration line was drawn that corresponded to the concentration originally obtained from WHC-SD-WM-TI-565, Radionuclide and Chemical Inventories For the Single Shell Tanks (SSTs). Since the purpose of the review was to ensure that the unit doses calculated from this data was an upper bound, sample points that were higher than the concentration line was reviewed by a panel to determine if the higher points should be used for calculating the unit doses.

The review panel consisted of experienced personnel from the analytical laboratory, process chemistry, TWRS engineering, waste tank operations and safety analysis. Data base support was provided by ICF KEH. The review panel used their cumulative knowledge of the Hanford Chemical Separations processes, references on the history of the Hanford tank farms, and files of laboratory sample reports to evaluate the sample points. If the panel determined that all the points on the plot which were above the concentration line were not applicable, then the concentration represented by the line continued to be the concentration used for unit dose calculations. If the panel found a point above the concentration line that could not be eliminated, then that point became the basis for a new, higher concentration for unit dose calculations.

The panel documented their rationale for rejecting or accepting sample points on the scatter plots and on separate Concentration Data Evaluation forms which were filed with the scatter plots. As the review has been completed the recommended concentrations for each radionuclide was provided to Criticality and Radiological Analyses for calculation of unit doses.

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The following listed data represents the maximum sample activity concentration for use in the safety analysis effort to support the waste retrieval of Tank 241-C-106:

C-106 Solids

<u>Radionuclide</u>	<u>Concentration</u>
Am ₂₄₁	5.48 E7 Bq/L (decayed) ¹
Cm ₂₄₄	No data ²
Co ₆₀	3.0 E7 Bq/L (decayed) ³
Cs ₁₃₇	2.67 E10 Bq/L (decayed) ⁴
Eu ₁₅₄	5.04 E4 μ Ci/kg (not decayed)
Np ₂₃₇	No data ⁵
Pu ₂₃₈	No data ⁶
Pu _{239/240}	3.27 E8 (decayed) ⁷
Pu ₂₄₁	Calculate from Pu ₂₄₀
Y ₉₀	Equal to Sr ₉₀
Sr ₉₀	9.75 E10 Bq/L (decayed) ⁸

¹ Decayed to December 1994

² Data appears in WHC-SD-WM-SARR-016, Tank Farm HLW Compositions and Atmospheric Dispersion Coefficients for Use IN ASA Consequence Assessments

³ Decayed to December 1994

⁴ Decayed to December 1994

⁵ Data appears in WHC-SD-WM-SARR-016, Tank Farm HLW Compositions and Atmospheric Dispersion Coefficients for Use IN ASA Consequence Assessments

⁶ Data appears in WHC-SD-WM-SARR-016, Tank Farm HLW Compositions and Atmospheric Dispersion Coefficients for Use IN ASA Consequence Assessments

⁷ Decayed to December 1994

⁸ Decayed to December 1994

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Composite 100 Percentile

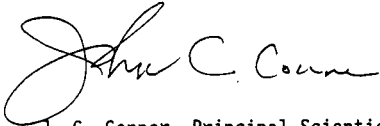
Nuclide	Volum. Activ. (Bq/L)	CEDE Dose (Sv/L)	Cont. (%)	Heat Load (W/L)	Cont. (%)	Lung Dose (Sv/L)	Cont. (%)	Bone Sur Dose (Sv/L)	Cont. (%)
C 14	1.2E 04	6.9E-06	0.0	0.0E+00	0.0	6.9E-06	0.0	6.9E-06	0.0
CO60	3.0E+07	1.8E+00	0.0	1.2E-05	0.1	1.0E+01	0.1	4.1E-01	0.0
SE79	0.0E+00	0.0E+00	0.0	0.0E+00	0.0	0.0E+00	0.0	0.0E+00	0.0
SR90	9.7E+10	6.3E+03	8.8	3.0E-03	14.0	3.6E+02	3.3	7.1E+04	5.7
Y 90	9.7E+10	2.2E+02	0.3	1.5E-02	67.0	9.1E+02	8.4	1.5E+00	0.0
ZR95	0.0E+00	0.0E+00	0.0	0.0E+00	0.0	0.0E+00	0.0	0.0E+00	0.0
TC99	1.2E+07	3.2E-03	0.0	1.6E-07	0.0	4.1E-03	0.0	5.2E-04	0.0
RU106	0.0E+00	0.0E+00	0.0	0.0E+00	0.0	0.0E+00	0.0	0.0E+00	0.0
SB125	0.0E+00	0.0E+00	0.0	0.0E+00	0.0	0.0E+00	0.0	0.0E+00	0.0
I 129	4.3E+03	2.0E-4	0.0	5.4E-11	0.0	1.3E-06	0.0	5.9E-07	0.0
CS134	0.0E+00	0.0E+00	0.0	0.0E+00	0.0	0.0E+00	0.0	0.0E+00	0.0
CS137	2.7E+10	2.3E+02	0.3	3.4E-03	15.7	2.4E+02	2.2	2.1E+02	0.0
CE144	0.0E+00	0.0E+00	0.0	0.0E+00	0.0	0.0E+00	0.0	0.0E+00	0.0
PM147	0.0E+00	0.0E+00	0.0	0.0E+00	0.0	0.0E+00	0.0	0.0E+00	0.0
EU154	1.1E+09	8.8E+01	0.1	2.8E-04	1.3	9.0E+01	0.8	6.0E+02	0.0
NP237	0.0E+00	0.0E+00	0.0	0.0E+00	0.0	0.0E+00	0.0	0.0E+00	0.0
PU238	1.4E+08	1.5E+04	20.5	1.2E-4	0.6	2.5E+03	23.5	2.6E+05	21.0
PU239	3.3E+08	3.8E+04	52.9	2.7E-04	1.2	5.7E+03	52.2	6.9E+05	55.2
PU240	0.0E+00	0.0E+00	0.0	0.0E+00	0.0	0.0E+00	0.0	0.0E+00	0.0
PU241	2.6E+09	5.7E+03	7.9	2.1E-6	0.0	1.9E+01	0.2	1.1E+05	8.6
AM241	5.5E+07	6.6E+03	9.2	4.9E-05	0.2	1.0E+03	9.3	1.2E+05	9.5
AM242M	0.0E+00	0.0E+00	0.0	0.0E+00	0.0	0.0E+00	0.0	0.0E+00	0.0
AM243	0.0E+00	0.0E+00	0.0	0.0E+00	0.0	0.0E+00	0.0	0.0E+00	0.0
CM242	0.0E+00	0.0E+00	0.0	0.0E+00	0.0	0.0E+00	0.0	0.0E+00	0.0
CM244	0.0E+00	0.0E+00	0.0	0.0E+00	0.0	0.0E+00	0.0	0.0E+00	0.0
EU155	0.0E+00	0.0E+00	0.0	0.0E+00	0.0	0.0E+00	0.0	0.0E+00	0.0
Total	2.3E+11	7.2E+04		2.2E-2		1.1E+04		1.3E+06*	

* Indicates whole body or organ limited.

J. W. Bailey, et al
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8M110-JCC-95002

The listed data of the 25 chemicals will be provided at a future date. If you have any questions, please contact me at 376-2058.

A handwritten signature in cursive script that reads "John C. Conner". The signature is written in black ink and is positioned above the typed name.

J. C. Conner, Principal Scientist
TWRS Safety Engineering

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Environmental Assessment

Tank 241-C-106 Past-Practice Sluicing Waste Retrieval,
Hanford Site, Richland, Washington

U.S. Department of Energy
Richland, Washington

February 1995

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DOE/EA - 0933

ENVIRONMENTAL ASSESSMENT

**TANK 241-C-106
PAST-PRACTICE SLUICING
WASTE RETRIEVAL**

HANFORD SITE, RICHLAND, WASHINGTON

U.S. DEPARTMENT OF ENERGY

February 1995

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Glossary

Acronyms and Initialisms

ALARA	As Low As Reasonably Achievable
Btu	British thermal unit
CAA	<i>Clean Air Act of 1970</i>
CPS	Criticality Prevention Specification
CRR	Cultural Resources Review
CY	Calendar Year
DBE	Design Basis Earthquake
DOE	U.S. Department of Energy
DOH	State of Washington Department of Health
DST	double-shell tank
EA	Environmental Assessment
Ecology	State of Washington Department of Ecology
EDE	Effective Dose Equivalent
EPA	U.S. Environmental Protection Agency
HEPA	High-Efficiency Particulate Air
HVAC	heating, ventilation, and air conditioning
kW	kilowatts
LCF	latent cancer fatality
MEI	maximally exposed individual
NRC	Nuclear Regulatory Commission
RCRA	<i>Resource Conservation and Recovery Act of 1976</i>
rem	roentgen equivalent man
SST	single-shell tank
Tri-Party Agreement	<i>Hanford Federal Facility Agreement and Consent Order</i>
TRU	transuranic
WAC	<i>Washington Administrative Code</i>

Definition of Terms

As Low As Reasonably Achievable (ALARA). An approach to radiation protection to control or manage exposures (both individual and collective to the workforce and general public) as low as social, technical, economic, practical, and public policy considerations permit.

Double-shell tank. A reinforced concrete underground vessel with two inner steel liners to provide containment and backup containment of liquid waste; annulus is instrumented to permit detection of leaks from the inner liner.

Definition of Terms (cont.)

Effective Dose Equivalent. A value used for estimating the total risk of potential health effects from radiation exposure. This estimate is the sum of the committed effective dose equivalent from internal deposition of radionuclides in the body and the effective dose equivalent from external radiation received during a year.

High-heat waste. Liquid radioactive waste which has the potential to generate sufficient fission product decay heat to cause self-boiling and self-concentration.

High-level waste. The highly radioactive waste material that results from the processing of spent nuclear fuel, including liquid waste produced directly in reprocessing that contains a combination of transuranic waste and fission products in concentrations requiring permanent isolation.

Latent cancer fatality. The additional cancer fatalities in a population due to exposure to a carcinogen.

Low-level waste. Waste that contains radioactivity and is not classified as high-level waste, transuranic waste, or spent nuclear fuel or byproduct material where the concentration of transuranic radionuclides is less than 100 nCi/g.

Maximally exposed individual. A hypothetical member of the public residing near the Hanford Site who, by virtue of location and living habits, could receive the highest possible radiation dose from radioactive effluents released from the Hanford Site.

Person-rem. A population dose based on the number of persons multiplied by the radiation dose.

rem. Acronym for roentgen equivalent man; a unit of dose equivalent that indicates the potential for impact on human cells.

Single-shell tank. Older style Hanford Site high-level waste underground tank composed of a single carbon steel liner surrounded by concrete.

Sluicing. A method of waste retrieval which utilizes a high-volume, low-pressure stream of liquid to mobilize the waste prior to pumping.

Supernatant. The relatively clear liquid which is located over material deposited by settling or precipitation.

Transuranic waste. Without regard to source or form, radioactive waste that at the end of institutional control periods is contaminated with alpha-emitting transuranic radionuclides with half-lives greater than 20 years and concentrations greater than 100 nCi/g.

Definition of Terms (cont.)

Watch List tanks. These tanks have been identified as Watch List Tanks in accordance with Public Law 101-510, Section 3137, *Safety Measures for Waste Tanks at Hanford Nuclear Reservation, 1990*. These tanks have been identified as the Priority 1 Hanford Site Tank Farm Safety Issues: "Issues/situations that contain most necessary conditions that could lead to worker (onsite) or offsite radiation exposure through an uncontrolled release of fission products, e.g., Tank SY-101."

Metric Conversion Chart

If you know	Multiply by	To get
Length		
centimeters	0.39	inches
meters	3.28	feet
kilometers	0.62	miles
Area		
square kilometers	0.39	square miles
square centimeters	0.16	square inch
Mass (weight)		
grams	0.035	ounces
kilograms	2.20	pounds
milligrams	2.20×10^4	pounds
Volume		
liters	0.26	gallons
cubic meters	35.3	cubic feet
Temperature		
Celsius	multiply by 9/5ths, then add 32	Fahrenheit
kilowatts	3412.14	British thermal unit
Pressure		
kilograms per-square-centimeter	14.22	pounds per-square-inch

Source: *CRC Handbook of Chemistry and Physics*, Robert C. Weast, Ph.D., 70th Ed., 1989-1990, CRC Press, Inc., Boca Raton, Florida.

Scientific Notation Conversion Chart

Multiplier	Equivalent
10^1	0.1
10^2	.01
10^3	.001
10^4	.0001
10^5	.00001
10^6	.000001
10^7	.0000001
10^8	.00000001

Executive Summary

The U.S. Department of Energy (DOE) needs to take action to eliminate safety concerns with storage of the high-heat waste in Tank 241-C-106 (Tank C-106), and demonstrate a tank waste retrieval technology. This Environmental Assessment (EA) was prepared to analyze the potential impacts associated with the proposed action, past-practice sluicing of Tank C-106, an underground single-shell tank (SST). Past-practice sluicing is defined as the mode of waste retrieval used extensively in the past at the Hanford Site on the large underground waste tanks, and involves introducing a high-volume, low-pressure stream of liquid to mobilize sludge waste prior to pumping. This EA describes the proposed action, the affected environment, reasonable alternatives to the proposed action, and provides an analysis of the potential environmental impacts.

It is proposed to retrieve the waste from Tank C-106 because this waste is classified not only as transuranic and high-level, but also as high-heat, which is caused by the radioactive decay of strontium. This waste characteristic has led DOE to place Tank C-106 on the safety "Watchlist." Historically, water has been added to the tank to provide evaporative cooling of the waste and to prevent the sludge from drying out. In the absence of these water additions, the heat load in Tank C-106 might exceed allowable temperature limits with the potential for structural damage to the tank. The tank is currently classified as sound, but there is a concern that should the tank start leaking, continued water additions could result in an increased amount of waste released to the environment.

Specifically, this action would accomplish the following:

- Remove at least 75 percent of the high-heat waste, which would reduce the tank heat load to less than 11.72 kilowatts (kW) (40,000 British thermal units [Btu] per hour). Water additions could then be stopped, and the tank removed from the safety "Watchlist"

- Demonstrate one form of SST retrieval by October 1997 as called for in *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) milestone M-45-03a, "Initiate Sluicing Retrieval of C-106." DOE has committed to resolving the safety concerns of the waste tanks at the Hanford Site in a more expedient timeframe. Consequently, the accelerated schedule calls for an October 1996 date for the waste retrieval demonstration.

Past-practice sluicing would be accomplished by transferring waste from Tank C-106 to the receiver tank, Tank 241-AY-102 (Tank AY-102), an underground double-shell tank (DST). Two transfer lines would connect the tanks. One line would carry the slurry (the sluiced waste) to the DST, and the other would carry the supernatant liquid from the DST, which would be used to mobilize the waste in Tank C-106 to facilitate pumping and waste transfer. The primary equipment necessary for this action would include pumps in each of the tanks; sluicer(s) to remotely aim the sluice streams in Tank C-106; a slurry distributor in the DST; an air ventilation system on Tank C-106; and additional monitoring devices. To provide adequate receiving space in Tank AY-102, its supernatant would be pumped out prior to sluicing. It is proposed that supernatant from Tank 241-AY-101 (Tank AY-101) or other appropriate sluicing fluid would be used as the sluicing agent. This sluicing fluid, which may consist of chemically treated water, would be pumped to Tank AY-102 prior to sluicing. Chemicals may be added, as necessary, to prevent potentially undesirable waste characteristics or to control corrosion.

Several alternatives to the proposed action are discussed briefly in this document. They include:

- **Batch Transfer.** This alternative would use an accumulation tank of 189,000 liters (50,000 gallons) that would alternately hold the supernatant from Tank AY-102, and the slurry from Tank C-106. The transfers would occur when this accumulation tank was full, and not simultaneously.

- **Once Through--No Recycle.** This alternative would use a tanker truck to supply the sluicing medium instead of using the supernatant from Tank AY-102.
- **Limited Mixer Pump.** A tanker truck would provide the sluicing fluid which would utilize sluicers, and a combined mixer and transfer pump, to create a slurry which would be sent to the receiver tank in batches.
- **Recirculate Within a SST Via Mixer Pump.** Two mixer pumps would use the sluicing fluid, introduced by a tanker truck, to mobilize all the solids in Tank C-106. The tank contents would be transferred to the receiver tank.
- **Internal Recirculation.** In this alternative, the sluicing fluid from a tanker truck would be routed through a loop in the sluicing system. After the waste has formed a slurry, some of this waste would be sent to the receiver tank, while the rest would be reused as a sluicing fluid.
- **Hydraulic Mining.** A crane would lower a mining tool into the waste in Tank C-106, and shoot a high-pressure stream of liquid laterally. As the waste is pumped, a cavity forms in the layer of waste desired.
- **Center Pivot Dredge.** This alternative would retrieve the waste in Tank C-106 by mechanical dredging equipment which would access the tank by a new 1.5-meter (5-foot) opening.
- **No-Action.** This alternative would involve leaving the high-heat waste in Tank C-106, and continuing to add cooling water periodically.

These alternatives were examined and found to either pose a greater threat to the environment than the proposed action, or failed to meet one of the two requirements of this project. These requirements consist of reducing the heat load in Tank C-106 to below 11.72 kW (40,000 Btu per hour), and being able to start retrieval by October of 1996.

Impacts from the proposed action were found to be small in comparison to Hanford Site operations as a whole. Environmental impacts to the air and water would be within all applicable standards. The proposed action would not lead to a substantial increase in human health effects and would be in compliance with all standards pertaining to public health. No impact is expected to any threatened or endangered plant or animal species, critical or sensitive habitat, or cultural or historical resources.

Impacts from accidents were examined and evaluated. The worst-case scenario, for both onsite and offsite populations, would involve an unfiltered release through a breach in the recirculation duct of the ventilation system using Tank AY-101's supernatant as a sluicing fluid. The likely mechanism for this accident is a vehicular collision, however it is possible that a Design Basis Earthquake (DBE) could lead to similar results. It is assumed that one hour elapses before the leak is detected. This duration can be considered conservative due to the presence of design features which would shut off the sluicing operation, and identify a release, well before one hour. The offsite maximally exposed individual (MEI) has been calculated to receive a dose of 5.2×10^{-4} roentgen equivalent man (rem) Effective Dose Equivalent (EDE), which would represent a probability of 3.0×10^{-7} that the individual would develop a latent cancer fatality (LCF). The onsite MEI was calculated to receive 5.0×10^{-1} rem EDE. This dose would represent a probability of 2.0×10^{-4} that the onsite individual would develop an LCF. The effect to offsite and onsite populations from this scenario would be a calculated 0.0 and 0.02 LCFs, respectively.

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1.0 Purpose and Need for Agency Action

The U.S. Department of Energy (DOE) needs to take action to eliminate safety concerns with the storage of high-heat waste in Tank 241-C-106 (Tank C-106), and demonstrate a tank waste retrieval technology. The action would address the following concerns:

- The heat generation for Tank C-106 is estimated to be 32.24 plus or minus 5.86 kilowatts (kW) (110,000 plus or minus 20,000 British thermal units [Btu] per hour) (WHC 1993a). The heat is produced from the radioactive decay of radionuclides present in the waste, principally strontium-90. This decay heat is currently being removed by evaporative cooling. Approximately 22,700 liters (6,000 gallons) of water are added to the tank each month for this purpose. It is believed that without active cooling, temperatures in the tank would exceed established limits and eventually affect the structural integrity of the tank with a possible breach of containment.
- The continued addition of cooling water to the tank increases the amount of waste that could disperse into the soil column if Tank C-106 starts to leak. Even with the continued additions of cooling water, Tank C-106's integrity could still fail due to the fact that it is storing waste beyond its design life. In addition to the possibility of a tank leak occurring due to the age of the tank, a natural occurrence (i.e., an earthquake) also could lead to a release of the tank's contents to the environment. It is, therefore, advantageous to remove the waste from this tank as soon as possible to protect the environment against an accidental release.
- *Hanford Federal Facility Agreement and Consent Order (Tri-Party Agreement) Milestone M-45-03-T01, "Complete SST Waste Retrieval Demonstration,"* calls for the completion of a waste retrieval demonstration by 2003. Tank C-106 has been selected by DOE as the demonstration tank for this milestone. The State of Washington Department of Ecology (Ecology) has concurred in this selection and the Tri-Party Agreement names Tank C-106 as the retrieval demonstration tank. Sluicing has been identified as a reference retrieval technology for single-shell tank (SST) waste. While past-practice sluicing has been practiced extensively at the Hanford Site, it is identified as a demonstration technology because it has to be proven effective under the current regulatory framework which is much more stringent than past requirements. Sluicing will be evaluated as a method of waste retrieval for all SSTs. Tri-Party Agreement Milestone M-45-03a, "Initiate Sluicing Retrieval of C-106," also calls for the initiation of sluicing retrieval of Tank C-106 by October of 1997 to resolve the high-heat issue. This project has been identified by DOE as a Secretary of Energy Safety Initiative, and its schedule has been accelerated by one year over the date committed to in the Tri-Party Agreement. This reflects DOE's desire to resolve the safety issues surrounding specific waste tanks at the Hanford Site in a more expedient manner. The new, accelerated date proposed for initiation of the retrieval of the heat-generating waste from Tank C-106 is October 1996. Construction activities required prior to sluicing operations would last approximately two years, while the actual waste retrieval activities would take between six months and one year.

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2.0 Description of the Proposed Action

2.1 Background

The *National Defense Authorization Act for Fiscal Year 1991*, Public Law 101-510, Section 3137, "Safety Measures for Waste Tanks at Hanford Nuclear Reservation," mandates that DOE develop plans to respond to safety issues associated with underground waste storage tanks on the Hanford Site, and report the progress of implementation of these plans to the U.S. Congress. The tanks identified as having safety issues associated with them belong to the safety "Watchlist." The report containing the response plans has been prepared as *Status Report on Resolution of Waste Tank Safety Issues at the Hanford Site* (WHC 1993b), which identifies Tank C-106 as one of the "Priority 1," safety issues at the Hanford Site.

The proposed action would involve sluicing the waste from Tank C-106, a SST, and transferring the waste to Tank 241-AY-102 (Tank AY-102), a double-shell tank (DST), through one of the two proposed double encased (pipe-in-pipe design), bermed lines. Past-practice sluicing involves introducing a high-volume, low-pressure stream of liquid to mobilize sludge waste prior to pumping. Tank C-106 is located in the 200 East Area (Figure 1). Tank C-106 is 23 meters (75 feet) in diameter, and is constructed of reinforced concrete with a carbon-steel liner on the tank bottom and sides. The tank has a 31-centimeter (12-inch) thick dished bottom, and a useable waste depth of approximately 4.8 meters (16 feet) at the sidewall. The dome of the tank is constructed of 38-centimeter (15-inch) thick reinforced concrete. Tank C-106 was constructed between 1943 and 1944, and has the capacity of approximately 1.9 million liters (500,000 gallons). Figure 2 shows the proposed configuration of Tank C-106.

In 1992, the ventilation system failed on the tank, and the practice of adding cooling water was halted for a period of six months while the ventilation system was being repaired. The tank was continuously monitored for waste level decreases that might indicate that there was a loss of confinement in the tank. During this period, the waste level in the tank did not decrease, but actually rose as a result of thermal expansion due to the increased temperature, which supported DOE's classification of the tank as sound.

The waste in Tank C-106 consists of 746,000 liters (197,000 gallons) of sludge. The waste is stratified into two layers. The top layer consists of 655,000 liters (173,000 gallons) of sludge, containing a sufficient amount of strontium to be considered high-heat waste (WHC 1993a). This layer generates approximately 32kW (110,000 Btu per hour). The bottom layer consists of 91,000 liters (24,000 gallons) of low-heat producing hardened material. Approximately 121,000 liters (32,000 gallons) of supernatant exists above the sludge layers, and would be pumped to Tank AY-102 as part of this project, just prior to sluicing operations. In order to resolve the heat issue associated with this tank, sluicing would need to remove approximately 75 percent of the high-heat waste to lower the heat output of the remaining waste to less than 11.72 kW (40,000 Btu per hour). Before the

addition of the strontium bearing waste in the 1970s, Tank C-106 did not exhibit a heat problem. There was also an observable hardened layer at the bottom of the tank. After the sluicing operation which introduced the strontium waste was completed, the level of solids in Tank C-106 was observed to increase. At the same time, the waste started generating excess amounts of heat. Figures 3 and 4 show Tank C-106's volume history and heat generation, by layer, respectively.

A core sample taken from Tank C-106 in 1986 showed that stratification of the waste layers persisted. The bottom layer was observed to remain as a hardened layer while the upper layer still remained a soft sludge. It was concluded that since the layers did not commingle, the constituents generating heat remained in this upper soft layer.

In addition to producing significant quantities of heat, the waste in Tank C-106 has greater than 100 nanocuries per gram transuranic (TRU) content (WHC 1994a). This qualifies the sludge as both a high-heat and TRU waste (WHC 1993a). The chemical composition of the sludge also classifies the contents of the tank as a "listed waste" in accordance with *Washington Administrative Code* (WAC) 173-303, "Dangerous Waste Regulations." The heat generation rate for this sludge is estimated to be 32.24 plus or minus 5.86 kW (110,000 plus or minus 20,000 Btu per hour) (Bander 1993).

Tank AY-102, which also is located in the 200 East Area, was built between 1968 and 1970, and has an operational capacity of 3.7 million liters (980,000 gallons). Tank AY-102 is currently near its operational capacity, but would undergo a waste transfer operation prior to sluicing to provide receiving space for Tank C-106's waste. The tank is currently classified as sound (WHC 1993a), and was built with a design life of 50 years. Tank AY-102's waste comes from a variety of sources and is considered TRU and of a noncomplexed organic nature, which poses no criticality issues with the waste from Tank C-106 (WHC 1994a). Tank AY-102 was chosen as the receiver tank because it is a DST, which provides an additional barrier against the release of the waste to the environment; has a newer, larger capacity ventilation system which can dissipate much larger amounts of heat; and has a sufficient amount of space available for waste storage. The transfer of the waste to this DST would eliminate the high-heat problem associated with the waste because Tank AY-102's ventilation system (which serves four DSTs) is capable of handling 1,173 kW (4 million Btu per hour). Tank AY-102 would store the waste until final treatment options become available (currently scheduled for the Year 2009). Figure 2 shows the proposed configuration of Tank AY-102.

2.2 Proposed Action

The proposed action would remove the high-heat solids in Tank C-106 by a closed-loop, continuous sluicing process. Specifically, this would entail introducing a high-volume, low-pressure stream of liquid (supernatant or treated water) to mobilize the sludge waste in Tank C-106 and prepare it for pumping. Up to two remotely aimed "sluicers" would be installed in Tank C-106 at separate locations to ensure full sluicing coverage of the waste. As soon as the sludge is broken up by the sluicers, and a slurry formed, a slurry transfer pump would remove the mixture for transfer to the receiver tank at approximately the same

rate that the supernatant is being introduced to Tank C-106. The waste would be transferred to Tank AY-102 through one of two proposed, double encased pipelines, which would be installed to support this waste retrieval project. These pipelines, which would connect the two tanks, would measure approximately 0.4 kilometer (0.25 miles) in length. Figure 5 depicts tank-to-tank sluicing while Figure 6 shows the location of the proposed waste transfer lines. The slurry would be deposited in Tank AY-102 through a slurry distributor (located below the liquid level), which would greatly diminish the flow velocity and allow the heavier, sludge particles in the slurry to settle under the force of gravity. The liquid portion of the slurry would remain on top to be recycled to Tank C-106 as the liquid sluicing agent (supernatant). A sluice pump would simultaneously transfer the supernatant from Tank AY-102 to Tank C-106 through one of the two, newly installed, pipelines to the sluicers where it would be used to mobilize additional sludge in Tank C-106. The pipelines would be partially buried and covered with an earthen berm to limit personnel dose exposure to tank farm workers (Figure 7).

At the beginning of the sluicing operation, the 120,000 liters (32,000 gallons) of supernatant presently in Tank C-106 would be pumped to the receiver tank (which would be approximately half full at the time of sluicing) to allow improved sluicing efficiency in Tank C-106. The valves on the slurry transfer pump in Tank C-106 then would be set to allow the slurry to recirculate directly to the sluicers. This process would allow the mixture recirculating within Tank C-106 to be monitored for waste consistency. Once the slurry has the desired characteristics (mainly for percentage of solids), the valves on the slurry transfer pump would be switched to allow the slurry to pump through the transfer line to Tank AY-102. At this point, the maximum amount of supernatant pumped from Tank AY-102 would be roughly 19,000 liters (5,000 gallons). The sluice pump would send the supernatant simultaneously from Tank AY-102 to the sluicers, creating a continuous process.

During this process, the sluice pump in Tank AY-102 would deliver 1,324 liters (350 gallons) per minute of supernatant to the sluicing nozzles in Tank C-106, with a pressure of 12.5 kilograms per-square-centimeter (180 pounds per-square-inch), and a temperature between 24 and 29 °C (75 to 85 °F). This pump maintains enough agitation to prevent any solids from settling in the transfer lines. Up to two sluicers (Figure 8) would be installed in Tank C-106, and would use the supernatant from Tank AY-102 to break up the sludge waste. One sluicer would operate in the existing sluice pit, while the other would operate in the existing pump pit, if needed. During most of the waste retrieval operations, only one sluicer would operate at any given time.

An in-tank imaging system would be used to monitor the operation of the sluicers by locating sludge concentrations, and determining the effectiveness of the sluicers. This imaging system would allow for sluicing operations to proceed with a minimal volume of liquid in Tank C-106, which is desirable for safety (tank leakage) considerations and proper positioning of the sluicers for maximum solids removal efficiency. The sluicers would be directed with the aid of this imaging system to cut troughs in the waste during the initial stages of waste removal. These troughs, which would produce channels in the waste leading to the slurry pump, would increase sluicing efficiency (Figure 9).

A new submersible pump would be installed in Tank C-106 to transfer the slurry (i.e., the sluiced waste) to Tank AY-102. To allow for slurry elevation changes, the slurry transfer pump would be manually adjusted to maintain sufficient suction-head pressure. The sluicing operations would start from the center of the tank, and work to the outside, by remotely adjusting the angle of the sluicers. The waste solids located along the tank walls would not be removed until the end of sluicing operations (Figure 9). This would minimize the potential for the sluicing stream to cause a leak by impinging upon a weak point in the tank wall or by opening a pre-existing corrosion induced or sludge-plugged leak site.

The slurry would be pumped into the transfer line and deposited into Tank AY-102. A slurry distributor would evenly spread the Tank C-106 waste solids in Tank AY-102. This would provide a more uniform heat source in Tank AY-102. The distributor also would provide a siphon break for the transfer line back to Tank C-106.

Various techniques exist for determining the amount of sludge the sluicing operation has transferred from Tank C-106. Two of these techniques include direct observation by the in-tank imaging system and the use of process instrumentation. Instrumentation included in the transfer lines would offer a direct measurement of the quantity of waste transferred. In addition to assessing the amount of sludge transferred, the sluicing system proposed for this operation, combined with the level indicator located in Tank AY-102, could be used to determine whether Tank C-106 has developed a leak. A running material balance inventory would be maintained to assure that all liquids (within the accuracies of the Tank AY-102's liquid level instrument and the transfer lines' flow meters) remain accounted for. The presence of flow meters on the transfer lines and material balance controls on Tank AY-102 would detect a leak when approximately 30,000 liters (8,000 gallons) are removed from the sluicing process by means of a leak somewhere in the closed-loop system.

Determination of the end point for the sluicing operation would depend on the results of an in-field evaluation to determine the heat balance of Tank C-106. When the majority (at least 75 percent) of the high-heat waste has been transferred, the evaluation may be considered, although the evaluation may be conducted at other times if other situations arise. If this evaluation confirms that the heat load in the tank is below 11.72 kW (40,000 Btu per hour), the sluicing operation could end; however, additional waste might be sluiced to demonstrate the effectiveness of this waste retrieval technology.

Chemical additions of sodium hydroxide and sodium nitrite (to maintain the waste within the DST operating specifications for corrosion control), would be distributed through an existing riser in Tank AY-102, as needed. In addition, caustic solution (namely sodium hydroxide) would be added, as necessary, to the supernatant prior to and during sluicing to promote waste compatibility.

The project would be designed to incorporate features that would protect workers. The waste transfer lines would be partially buried and bermed for radiation shielding. The proposed new ventilation system for Tank C-106 would be designed to reduce the time workers would spend changing filters. Workers in the 241-C Tank Farm would wear all of the appropriate protective clothing, and may use respiratory equipment (e.g., face masks and bottled 'fresh' air).

Prior to the actual sluicing operations, several actions would be required to prepare the tanks for the insertion of the pumps and/or equipment. Some of the existing equipment in the pump and sluice pits of Tank C-106 must be removed and stored at the Hanford Site for subsequent treatment and disposal. This removal would be accomplished by hoisting the equipment through existing risers into flexible receiver containers. These containers would be lowered into specially constructed crates positioned on a trailer, and sent to the Hanford Central Waste Complex. During the actual sluicing operation, it may be necessary to remove additional equipment if it is determined that this remaining, obsolete equipment impairs sluicing efficiency. The same method of equipment removal described above likely would be utilized for these removals as well. The inside of the pump and sluice pits would require cleaning, and the application of paint or fiber to the surface, to provide a surface that can be more easily decontaminated. Equipment removal and pit decontamination are routine tank farm activities, as previously considered in the preparation of the *Final Environmental Impact Statement: Disposal of Hanford Defense High-Level, Transuranic and Tank Wastes, Hanford Site, Richland, Washington* (HDW-EIS) (DOE 1987), and the *Environmental Assessment: Waste Tank Safety Program, Hanford Site, Richland, Washington* (DOE 1994).

It is proposed that the initial sluicing fluid used to sluice Tank C-106's waste would be Tank 241-AY-101's (Tank AY-101) supernatant or other appropriate fluid. Alternative sluicing agents may consist of supernatant, or fluid, from another waste tank (or waste stream at the Hanford Site) or "buffered" water (water which has been chemically treated for corrosion control). The decision on which fluid to use as the sluicing agent would consider factors such as waste compatibility, cost effectiveness, waste minimization guidelines, and coordination with ongoing tank farm operations. Prior to the transfer of the sluicing fluid into Tank AY-102, the supernatant currently in Tank AY-102 would be sent to the Evaporator Bottoms System or another DST because of potential waste compatibility concerns with the sludge in Tank C-106. This type of transfer is performed frequently at the Hanford Site, and is considered to be a routine action required for proper waste storage and treatment. The removal of Tank AY-102's supernatant, even with the introduction of the new sluicing fluid, would create approximately 1.9 million liters (500,000 gallons) of space in the receiver tank for this transfer and would eliminate the potential for overflow as a result of the proposed sluicing operation.

To minimize releases to the atmosphere from the ventilation system on Tank C-106, the proposed action would install a High-Efficiency Particulate Air (HEPA) filtration system for Tank C-106. Additional filtration elements (which could include mist eliminators and gas filtration units) would be included in this system as required to meet regulatory release requirements, such as Best Available Control Technology for both toxic and radionuclide emissions. These additional elements would be added before sluicing operations commence if ongoing air emission studies demand their inclusion. New exhaust ductwork would be designed and installed to discharge through the new filtration system. The old ventilation system and ductwork would remain in place and operational for Tank 241-C-105 and Tank C-106 major maintenance operations. During these infrequent major maintenance operations, an air flow of approximately 75 cubic meters (2,500 cubic feet) per minute would

be discharged through this ventilation system. The new filtration system would discharge a maximum of approximately 9.9 cubic meters (350 cubic feet) per minute during normal operations. Section 5.1 presents a description of emissions from sluicing operations.

A metal filtration unit would be installed upstream from the HEPA filtration units, which would catch the majority of the contaminants before they reach the HEPA filters. This would negate the need to change these HEPA filters during the operational life of this project. This metal filtration unit would be included to meet As Low As Reasonably Achievable (ALARA) requirements, which are designed to minimize worker exposure to radioactive air emissions. Since the metal filtration unit is flushable, little or no solid waste is expected to be generated by the entire air filtration system. At the conclusion of these waste retrieval activities, the disposable part of these filter units would be disposed of properly at the Hanford Site.

To control the temperature and humidity of the Tank C-106 vapor space during sluicing, the proposed action would install a recirculation line in the ventilation system. This recirculation line would consist of a condenser, a dehumidification coil, and a recirculation fan. The proposed action would include a supplemental cooling system, if necessary, to provide a means of removing excess heat from the tank and to preclude steam generation from within the waste. A supplemental cooling system would allow sluicing to proceed safely and more efficiently. This cooling may be accomplished by modifying the piping on the ventilation system to allow the use of the proposed recirculation duct air chiller with the existing tank ventilation system or may involve the addition of cooling liquid (e.g., water), either prior to, or as part of, the sluicing process.

Additional instrumentation would be required in both tanks (Tanks C-106 and AY-102), and in the transfer lines between the tanks. Tank C-106 would receive instrumentation that would monitor tank pressure to ensure confinement. Temperature monitoring would be provided by using a thermocouple tree. Sluicing pump control and status instrumentation also would be provided. A double-wide trailer would be installed outside the 241-C Tank Farm, and would serve to house centralized monitoring and control instrumentation. Additional monitoring devices would be installed in Tank AY-102, as needed. Leak detection would be provided for the new transfer lines and the pump pits, and a seismic switch would be added to reduce the volume of a spill from a rupture of the transfer lines that could be caused by a Design Basis Earthquake (DBE).

Support services in the form of raw water, sanitary water, electrical power, telecommunications, and hoisting hardware, would be provided. The use of existing septic systems or portable facilities for sanitary sewage would be considered for the personnel using the control trailer. A sanitary catch tank, sized for one week of operation, may be provided should it be determined that existing facilities are inadequate. This catch tank would be emptied periodically (weekly) to a properly sited facility for treatment in accordance with approved Hanford Site procedures. Standby power and/or uninterruptable power supplies would be provided, as required.

The project has a maximum design life of two years, although actual sluicing operations should take approximately six months to complete. After the retrieval operation is complete, the used equipment and waste transfer lines would be decontaminated and stored for future treatment and disposal. Other project waste would be disposed of in a properly sited landfill in accordance with all applicable state and federal guidelines.

This project is designed to, at a minimum, remove 75 percent of the high-heat waste, which would lower the heat output of the remaining waste to less than 11.72 kW (40,000 Btu per hour). Sluicing would attempt to remove as much waste as possible beyond this 75 percent to demonstrate a waste retrieval technology. At the end of sluicing operations, however, a 0.3- to 0.6-meter (1- to 2-foot) layer of hardened waste may remain. This hardened layer, if not removed during the sluicing operation, would be removed by a different technology which is under development as part of a separate project, and will be addressed by future *National Environmental Policy Act of 1969* documentation. In the interim period, between the conclusion of the proposed action and the initiation of this future retrieval action, the hardened layer would be monitored and treated (e.g., removing any potential excess heat by utilizing air chillers, and sprinkler systems), if necessary, to prevent this waste from drying out and potentially developing undesirable characteristics. The waste in Tank AY-102 also would be monitored to ensure that the storage of waste is within the tank's operating specifications. Proper measures would be taken, which may include the use of airlift recirculators, to prevent the waste from forming potentially hazardous physical properties.

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3.0 Alternatives to the Proposed Action

Sluicing alternatives to the proposed action were identified and described in Appendix F of the *Tank 106-C Sluicing Letter Report* (WHC 1993c). The sluicing alternatives mentioned, including the No-Action Alternative, are listed below. Section 5.3.1 contains a discussion of the impacts from these alternatives.

- **Batch Transfer**. This option would utilize a 189,000-liter (50,000-gallon) accumulation tank, which would hold both the supernatant from Tank AY-102, and the slurry from Tank C-106, alternately. This supernatant would be used as the sluicer fluid for Tank C-106 waste. When enough solids were pumped to the accumulation tank, the material would be batch transferred to Tank AY-102. The accumulation tank then would be refilled with supernatant from Tank AY-102, and the cycle repeated. While definitive design for this alternative has not been completed, it is anticipated that the accumulation tank would be located within the 241-C Tank Farm boundaries. This alternative has been used at the Hanford Site as a proven technology used to retrieve waste.
- **Once Through--No Recycle**. This alternative would use a tank truck to supply the sluicing medium to mobilize the solids in Tank C-106, which are then pumped to the receiver tank. With no recycling, the amount of liquid, most likely raw water (chemically adjusted for corrosion control), pumped to the receiver tank would be larger, relative to the amount of liquid pumped from the proposed action. Some of this excess liquid would be pumped from the DST for additional treatment or storage (i.e., sent to an evaporator or another DST with more available space). This alternative, one of several which would use a tank truck, would allow for continuous operation.
- **Limited Mixer Pump**. This alternative is similar to the Once Through--No Recycle described above in that it would utilize a tank truck to provide the sluicing agent. This alternative, however, would use sluicers and a specially designed combined mixer and transfer pump to mobilize a portion of the solids in Tank C-106 in a bowl-shaped depression (utilizing the remaining solids as an additional barrier to tank leakage). The homogenized slurry then would be transferred to the receiver tank in batches to reduce the amount of extra liquid waste produced. While this alternative is not expected to produce as much additional waste as the Once Through--No Recycle Alternative, it still would require more storage space than the proposed action or the Batch Transfer Alternative.
- **Recirculate Within a SST Via Mixer Pump**. Again, a tank truck would be used to supply the waste mobilizing agent. However, sluicers would not be used in this option. Instead, two mixer pumps would use the introduced liquid to mobilize all of the solids in Tank C-106 into a homogenous slurry before transfer. This option would have roughly the same waste space requirements as the proposed action; however, there are several drawbacks that make this option unattractive. These

drawbacks include higher heat input to the waste due to additional mixing and agitation; increased environmental risk due to possible damage to the tank from the mixing pump outlet spray impinging on the tank walls and a much higher liquid inventory maintained in Tank C-106 during the retrieval operation; the need for an additional 107-centimeter (42-inch) riser; and a longer design and testing period.

- **Internal Recirculation.** The last alternative examined using a tank truck, internal Recirculation, would use a portion of the slurry (i.e., the already-slucied waste) as an additional mobilization agent. Some of the slurry would be pumped to the receiver tank, and some would be fed back into the sluicers. This would limit the amount of mobilization agent needed from the tank truck. As with the other alternatives that use a tank truck, the amount of slurry waste would be somewhat greater than that of the proposed action.
- **Hydraulic Mining.** This alternative would use a variation of a technique used in the mining industry. A crane would lower a mining tool that would penetrate the waste and shoot a high-pressure stream of water laterally. A slurry inlet port would pump the slurry out to the receiver tank, creating a waste cavity in the section of waste desired. More complex than the proposed action, this unproven alternative would have the potential for the greatest waste minimization of any of the alternatives. However, the amount of time required to develop and test the method would be much greater than any of the other alternatives.
- **Center Pivot Dredge.** Dredging involves utilizing a 1.5-meter (5-foot) opening to allow mechanical dredging equipment to access the tank. This option involves the highest cost and complexity, and yet provides the lowest probability of success because of the technical difficulty of dredging around obstructions (i.e., failed equipment and instrumentation), which extend from the risers. In addition, the amount of time needed to test and develop appears to be prohibitive. The exposure to workers is anticipated to be higher due to the 1.5-meter (5-foot) opening. Concerns on exceeding tank dome weight limits also exist with this option. The potential for worker exposure is greater, and the amount of equipment to be decontaminated and decommissioned is larger.
- **No-Action.** This alternative would involve leaving the high-heat waste in Tank C-106 and continuing to add cooling water.

Of the sluicing alternatives presented above, only the proposed action and the Batch Transfer Alternative meet the two requirements considered essential to addressing the concerns mentioned in Section 1.0. These requirements consist of reducing the heat load in Tank C-106 to less than 11.72 kW (40,000 Btu per hour), and choosing a sluicing method that would be capable of starting retrieval by October of 1996. The other alternatives were not capable of meeting one or both of these requirements and, therefore, were not examined further. The Batch Transfer Alternative, while it meets the two requirements, would entail more design, procurement and construction costs, and would be less likely to meet the start date.

The No-Action Alternative would result in maintaining Tank C-106 in its present condition. No waste transfer operations would be performed, and the high-heat producing waste would continue to generate excessive thermal loads. In order to maintain the temperature of the tank to levels below the point where the tank structural integrity would not be affected by excessive heat, cooling water would continue to be added. Alternative means of cooling the waste, such as using a sprinkler system, an air chiller (which would introduce cooled air into the tank), or a combination of the two, are currently being examined. These cooling methods are designed to be used as a contingency plan should the tank start to leak. Because Tank C-106 has reached the end of its design life, the possibility of a tank leak is fairly high and will increase over time. The continued addition of cooling water, which would likely proceed under the No-Action Alternative, would increase the total amount of possible contamination which could leak into the soil column. No matter which cooling method is used (either the addition of cooling water or the development and use of an air chiller), the problem of high-heat producing waste would persist, and the Tri-Party Agreement milestone (M-45-03-T01) for the demonstration of a waste retrieval technology would not be met.

Alternatives to the use of Tank AY-102 as the receiver tank were examined at the inception of this project. All DSTs in the 200 East Area were examined as potential receiver tanks. The SSTs were excluded due to fact that most, if not all, of the SSTs are beyond their design life and do not meet double containment requirements. Of the DSTs examined, only the Aging Waste Facility (including two tanks in the AY Tank Farm and two tanks in the AZ Tank Farm) contained a ventilation system capable of handling the additional heat load of Tank C-106's waste. Only the two tanks within the AY Tank Farm were found to have sufficient storage space. Later analyses examined the waste forms from both of the AY tanks for compatibility, and found the best waste compatibility aspects in terms of storage to be with the Tank AY-102. As was mentioned earlier, it has been determined that the supernatant from Tank AY-101 would be used as the initial sluicing agent.

No other reasonable alternatives to past-practice sluicing have been identified.

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4.0 Affected Environment

4.1 Hanford Site

Tanks C-106 and AY-102, are located in the 200 East Area of the approximately 1,450 square kilometer (560 square mile) semi-arid Hanford Site in Southeastern Washington State (Figure 1). The 200 East Area is approximately 10 kilometers (6 miles) west of the Columbia River, the nearest natural watercourse. The nearest population center is the City of Richland, approximately 32 kilometers (20 miles) to the south. The City of Richland has a population of 32,315, while the population within an 80-kilometer (50-mile) radius of the 200 Areas is approximately 380,000. Roughly 2,800 employees are working in the 200 East Area, and an estimated 20 workers would be directly involved with the sluicing operations. The 200 East Area is not located within or adjacent to a wetland, or in a 100- or 500-year floodplain.

The geology of the site where the proposed action would take place is typical of the 200 Areas. The surface is covered with loess and sand dunes of varying thickness, although the tank farms and the majority of the area between them is composed of a disturbed gravel layer. Under the surface layer, in ascending order, are basement rocks of undetermined origin, the Columbia River Basalt Group with intercalated sediments of the Ellensburg Formation, the Ringold Formation, the Plio-Pleistocene unit, and the Hanford Formation. The depth to groundwater in the 200 East Area is 75 meters (246 feet). Groundwater flow is generally in an easterly and southeasterly direction, toward the Columbia River (PNL 1994a).

The Hanford Site has a mild climate with 15 to 18 centimeters (6 to 7 inches) of annual precipitation, and infrequent periods of high winds of up to 128-kilometers (80-miles) per hour. Tornadoes are extremely rare; no destructive tornadoes have occurred in the region surrounding the Hanford Site. The probability of a tornado hitting any given waste management unit on the Hanford Site is estimated at 1 chance in 100,000 during any given year.

The region containing the Hanford Site is categorized as one of low to moderate seismicity. The annual probability (frequency) of a DBE has been determined to be 7.0×10^{-4} . The DBE determines the structural standards which a facility must meet.

Additional information regarding the Hanford Site can be found in characterization documents (PNL 1994a and PNL 1994b).

4.2 Cultural and Biological Resources

The Hanford Site is known to be rich in cultural resources, and contains many well-preserved archaeological sites dating back to both prehistoric and historical periods.

Over 10,000 years of human activity have left extensive archaeological deposits along the Columbia River shoreline and at well-watered inland sites. By virtue of their inclusion in the controlled Hanford Site, archaeological deposits have been spared some of the severe disturbances that have befallen unprotected sites in the area.

The proposed activities, past-practice sluicing and waste transfer operations, would not occur in a known environmentally sensitive area. The tank farms affected by the sluicing and waste transfer actions have been reviewed, and have not been found to contain any cultural resources. Appendix A contains the Cultural Resources Review (CRR) for the impacted area and states that, "due to the highly disturbed nature of the area, no cultural resources are expected." If the work being proposed uncovered any items of significance (e.g., bones and artifacts), work would be halted until proper mitigation measures are taken. Additional information regarding the Hanford Site's cultural and biological resources can be found in characterization documents (PNL 1994a).

No plants or animals on the federal list of "Endangered and Threatened Wildlife and Plants" (50 Code of Federal Regulations 17) are found in the immediate vicinity of the proposed action. Consequently, there is no need for formal consultation with the U.S. Fish and Wildlife Service. In addition, none of the several species of plants and animals, which are under consideration for formal listing by either the Federal Government or the State of Washington, would be adversely impacted by the proposed waste retrieval activities. In fact, there are relatively few species of either plants or animals found in the proximity of the proposed action due to the highly disturbed nature of the area. Appendix B contains the Ecological Survey for the impacted area, and states that no state or federal threatened, endangered, or candidate species would be adversely impacted.

5.0 Environmental Impacts

This section presents information on those potential environmental impacts that have been identified as a result of the proposed activities for past-practice sluicing of waste from Tank C-106 to Tank AY-102. Also, environmental impacts are presented for reasonably foreseeable accident scenarios, impacts from the reasonable alternatives to the proposed action, and cumulative impacts.

5.1 Analysis of Past-Practice Sluicing of Tank 241-C-106

It is expected that proper controls on the tank ventilation systems would operate in accordance with *Clean Air Act of 1970* (CAA) requirements for gaseous and particulate discharges to the atmosphere. The tank ventilation system would maintain a negative pressure inside of Tank C-106. This would keep the gaseous and particulate contents inside the tank in the event of planned or unforeseen openings of the tank risers. The HEPA filtration units would be employed at the Tank C-106 exhaust stack, which would satisfy ALARA principles, and meet state and federal regulatory requirements. These requirements would limit emissions from both tanks, Tanks C-106 and AY-102. Emissions from Tank C-106 as a result of sluicing operations, which are expected to be slightly higher than current levels, would represent only a small fraction of total Hanford Site tank farm emissions. In 1992, the average dose to the offsite maximally exposed individual (MEI), based on measured emissions, from the combined filtration stack which services Tanks C-106 and 241-C-105, was 6.23×10^{-7} millirems (DOE-RL 1993). The average dose to the offsite MEI from the operation of the AY and AZ Tank Farms for 1992 was 4.4×10^{-5} millirems (DOE-RL 1993). Since the four tanks which comprise the AY and AZ Tank Farms all release through a common ventilation stack, individual release data from Tank AY-102 is not available. This number is not expected to increase either during or after the waste transfer operation. The proposed action would not result in a greater impact from emissions to either on- or offsite populations than the status quo.

Most of the liquid necessary for the sluicing operations would be obtained from, and returned to, Tank AY-102. The overall amount of liquid in Tank C-106 would not increase substantially during sluicing operations because the amount of material being sluiced is approximately equal to the amount of supernatant added. During the initial stage of retrieval operations, the total amount of waste in Tank C-106 would be increased by roughly 19,000 liters (5,000 gallons) of supernatant from Tank AY-102. Additional liquid, which would consist primarily of clean water, might be required for sluicing-line cleanout, but would not be a significant increase in total volume used, and would be within the receiving tank's storage capacity.

Sanitary services for the support trailer would consist of either a buried catch tank designed to collect sanitary waste, which would need to be emptied weekly for the duration of the project, or portable facilities. The waste from the catch tank would be pumped to a trailer truck and sent to a properly sited facility for treatment in accordance with approved

Hanford Site procedures. A permit for this catch tank would be required from the State of Washington Department of Health (DOH) if this option is chosen.

The sluicing and slurry transfer lines would comply with *Resource Conservation and Recovery Act of 1976 (RCRA)* requirements, and include full pipe-in-pipe containment with leak detection capability. The sluicing line valve box would be designed to have a drain system capable of handling a worst-case spill scenario. This drain system also would serve to prevent releases to the environment. Initially, sluicers would direct the diluted supernatant toward the center of the tank. As the retrieval operation proceeds, the sluicers would be directed outward. This would minimize the time that the tank liner is directly exposed to the sluice stream, and minimize the potential for a sluicing-induced tank leak.

During normal sluicing operations, no releases of tank contents would be expected. During jumper change operations (which is defined as the replacement of the hoses which connect the transfer lines to the various pumps, and sluicers), small residual amounts of radioactive material would be available for release. Leaks within the pump and sluice pits would be detected by special instrumentation which might include conductivity probes. Pit drains would return leaked wastes to either Tank C-106 or Tank AY-102 for compatible waste storage. Leaks resulting in measurable accumulation of solution on the floor of the pits would be detected, and the waste returned to the tank. For smaller leaks, detection would be accomplished by visual inspections or engineered features. The pits would maintain slightly negative pressures, maintained by the tank ventilation system, to prevent release of any airborne radioactivity from the pit to the atmosphere during retrieval activities. Administrative controls, such as lock and tag procedures, would require that all pit covers be in place before any transfer. The transfer pumps would be locked and tagged-out while the pit covers are off. The removal of the pump lock and tag requires that the pit covers be in place. Only after the lock and tagout requirements are met, would the pumps be allowed to operate. Spray and washdown systems would be incorporated into the design to reduce any contamination in the pits before they are opened for any maintenance activities.

Leaks in the primary piping system of the transfer lines would be controlled by the secondary containment system (the outer encasement pipe). This secondary containment system would be designed to collect released waste at a common point for detection and removal. Leaks from the DST would be controlled by the secondary containment shell, which is designed to collect and transmit released waste to a common point for detection and transfer. Inspection for potential leaks and waste transfer would be possible through a number of risers located on the DST.

There would be some radiological exposure to workers involved in the proposed activities. However, the anticipated exposure would be no greater than other routine tank farm activities. Average occupational external exposure to workers in the Hanford Site tank farms (as measured by individual dosimetry records) is approximately 14 millirem per year per worker (WHC 1994b), which is substantially less than the maximum allowable exposure of 5,000 millirem per year as set by DOE guidelines. For comparison purposes, the national average dose to the public from natural sources is 300 millirem per year (PNL 1994b).

Some additional exposure might occur to workers involved in decontamination of excess equipment at the conclusion of sluicing operations. Decontamination is considered a routine action at the Hanford Site. Engineering controls would be in place prior to decontamination activities to prevent any excess radiological exposure. Further, the workers are trained and would be attired in appropriate protective gear. Therefore, workers would not be expected to receive more than the allowable 5,000 millirem per year set by DOE guidelines. Also, decontamination activities could lead to exposure of hazardous chemicals used in the decontamination process. Proper training, equipment, and procedures would prevent adverse human health effects from the handling of these hazardous chemicals.

Workers involved with the sluicing operation would use proper respiratory equipment as required, (which may include masks and bottled 'fresh' air) while in the 241-C Tank Farm for the duration of the project, to avoid the possibility of inhalation of toxic vapors, which may emanate from other tanks (notably Tank 241-C-103). Tank C-106 is not expected to produce toxic vapors in detectable quantities and no threat to worker safety is predicted. Toxic air pollutants from routine operations would be within acceptable source impact levels at the Hanford Site boundary, and would pose no threat to the public.

Based on a dose-to-risk conversion factor of 4.0×10^{-4} (onsite) latent cancer fatality (LCF) per person-rem (56 *Federal Register* [FR] 23363), the average tank farm worker with the previously mentioned dose rate of 14 millirem per year would have an estimated annual probability of an LCF induced by the radiation of 5.6×10^{-6} . The estimated probability of the worker dying from cancer induced by such radiation doses over the worker's projected exposure period (2 years) is approximately 1.1×10^{-5} (or 1 chance in 100,000). Further, assuming that annually 20 tank farm workers are directly involved with operations associated with the proposed actions, and those workers are exposed to the average annual dose rate for tank farm operations (i.e., 14 millirem), a total of 2.2×10^{-4} LCFs over the two year projected exposure period would be expected.

No public exposure above that currently experienced from Hanford Site operations would be anticipated as a result of these actions. As reported in the *Hanford Site Environmental Report 1993* (PNL 1994b), the potential dose to the hypothetical offsite MEI during Calendar Year (CY) 1993 from Hanford Site operations was 3.0×10^2 millirem. The potential dose to the 380,000 persons which constitute the affected population (defined as the number of people living within 80 kilometers [50 miles] of the source) from 1993 operations, was 0.4 person-rem. The 1993 average dose to the population was 1.0×10^{-3} millirem per person. The current DOE radiation limit for an individual member of the public is 100 millirem per year.

The proposed action would result in the generation of solid waste during the life of the project. Such waste would be surveyed and disposed of in the Hanford Site Solid Waste Landfill if uncontaminated, or another applicable, permitted location if found to be contaminated with hazardous or radioactive constituents. Transportation of hazardous and/or radioactive waste is considered a routine activity at the Hanford Site. Proper administrative controls and operating procedures would minimize the impact of transporting this waste. At the completion of activities, noncontaminated equipment would be excessed where applicable,

while contaminated materials and components would be packaged and stored in an onsite permitted facility as is the current practice.

Trenching would be required for the installation of the transfer lines, power and instrumentation control cable lines, and for the tie-down operations required to install a double-wide trailer (two single, modular trailers combined into one facility). This facility would be located between the 241-C and the 241-AY Tank Farms. An Excavation Permit would be required for the trenching required for the power and instrumentation control cable lines, the buried waste transfer lines, and the tie-down operations needed for the double-wide trailer. Appendix A of this document is the CRR for this project, which states that no cultural resources are expected to be disturbed.

The area where the work is to be performed (i.e., the 241-C and 241-AY Tank Farms) is a developed, highly disturbed area, and is currently under vegetation management. The pipelines would be partially buried and covered with an earthen berm for shielding. Neither the pipelines nor the support facility would have a negative impact on plant or animal species of concern. The work would not disturb any sensitive or critical habitat. There are no animal species of special concern that are known to use the area exclusively. The 200 East Area is not located in a floodplain, and the tank farms are not located on land that could be considered wetlands. Appendix B consists of the Ecological Survey, which states that no adverse impacts are expected to any plant or animal species of concern because the proposed action takes place in such a highly disturbed location.

The proposed action likely would result in a minor release of particulates from construction activities needed to prepare the tanks for sluicing. These particulates, which consist chiefly of dust, would be mitigated by proper dust controls whenever necessary. Thermal discharges to the environment would be generated by equipment and vehicle exhaust, but can be considered minor when compared to sitewide thermal releases. Noise levels would rise in the vicinity of the 241-C and 241-AY Tank Farms during the sluicing operations, but would return to present levels when the project is finished. The equipment to be used (e.g., steel and other metals for piping and enclosures that are necessary for sluicing operations) represents a long-term commitment of nonrenewable resources. A Hanford Site Radiation Work Permit would be required for work within the tank farms.

Protective clothing requirements would be prescribed in the Hanford Site Radiation Work Permit and would be selected based upon the contamination level in the work area, the anticipated work activity, worker health considerations, and regard for any nonradiological hazards that may be present. The *Tank Farm Health and Safety Plan* (WHC 1994c) lists controls and procedures which are in place to protect tank farm workers. This document specifies clothing requirements (including respiratory equipment), monitoring procedures, tank farm access restrictions, and standard operating controls. In addition, workers would have completed all proper procedural and safety training prior to commencement of sluicing activities. This would result in having trained personnel present during all phases of the project, especially during the duration that the pumps are operating.

Construction activities would not generate any substantial risk to the existing operating facilities in the 200 East Area located near the waste transfer site. Routine construction

hazards would exist both before and during the retrieval operations. Field and construction operations would be conducted to ensure a safe working environment in accordance with both federal and state standards. The project would be designed to minimize the amount of hazardous and nonhazardous waste generated.

There would be no substantial effect to the work force at the Hanford Site, from either construction activities or during the actual sluicing operations. The 50 construction workers needed for work on the tank farms prior to sluicing would be taken from the existing local work force. As there would be no need for additional employees to be hired, there would be little effect on the local economy.

Neither the use of Tank AY-102 as the receiver tank nor the two preliminary supernatant transfers (from Tank AY-102 to the evaporator or another DST and from Tank AY-101 to Tank AY-102, if that is the sluicing agent chosen) would cause an adverse impact to the overall waste management strategy at the Hanford Site. The supernatant from Tank AY-102 would be sent to an evaporator for volumetric reduction before its subsequent storage in another DST. Such transfers at the Hanford Site occur routinely and are part of normal waste tank storage activities as described in the HDW-EIS (DOE 1987). For each of these routine transfers, a specific procedure, work plan, and/or work procedure would be written in accordance with approved DOE contractor procedures. Finally, these transfers would be evaluated to ensure that the DST storage criteria fall within an acceptable range for waste storage (i.e., temperature, chemical compatibility, organic material, and liquid level). No additional impact to human health or the environment would occur as a result of these transfers. Capabilities of DSTs other than Tank AY-102, either in existence or proposed, would exist to handle planned waste transfers in the future.

5.2 Analysis of Accidents

Table 1 displays the accident scenarios relevant to the proposed action. In addition, this section analyzes the issue of waste compatibility. For each accident scenario in the table, the probability of the accident occurring and the accident's potential impacts are provided. The consequences are conservatively presented assuming that Tank AY-101's supernatant is used as the sluicing agent. If another sluicing fluid is chosen that has a lower source term than Tank AY-101's supernatant, these doses likely would be lower. The probability for many of the accident scenarios is dependent on the probability of a DBE occurring at the Hanford Site. In fact, the worst case scenario for this sluicing operation would consist of a combination of the three accident scenarios discussed individually in this section. These scenarios consist of a DBE leading to an unfiltered release through a breach in the recirculation duct (which is not the only mechanism for this accident), a break in the waste transfer lines, and the rupture of Tank C-106. The presence of a DBE does not necessarily mean that all, or even some, of these accidents would happen, only that the mechanism exists which might lead to their occurrence. These accident scenarios were addressed in the *Preliminary Safety Evaluation for 241-C-106 Waste Retrieval* (WHC 1994a), an engineering study on leaks from Tank C-106 as a result of hydraulic retrieval (WHC 1993d), and a waste compatibility study (1994d). The range of reasonably foreseeable accident scenarios

associated with the proposed action, which could result in a release of radioactive materials to the environment, are discussed in detail following the table.

Table 1.
Reasonably Foreseeable Accident Scenarios.

Accident Scenario	Accident Consequences	Annual Probability	Reference Documentation
(1) Waste leak from jumper or connector	Offsite MEI dose of 1.6×10^{-4} rem EDE. Onsite dose of 1.5×10^{-1} rem EDE.	2.6×10^{-2}	WHC 1994a
(2) Waste transfer line leak	Offsite MEI dose of 1.0×10^{-4} rem EDE. Onsite dose of 1.9×10^{-1} rem EDE.	7.0×10^{-4} *	WHC 1994a
(3) Tank rupture due to DBE	Potentially large scale environmental contamination of soil and groundwater.	7.0×10^{-4} *	N/A (see text)
(4) Tank C-106 leak from sluicing	Release of substantial amounts of liquid waste to the environment (soil and possibly groundwater).	Undetermined (see text)	WHC 1993d
(5) Recirculation line breach	Offsite MEI dose of 5.2×10^{-4} rem EDE. Onsite dose of 5.0×10^{-1} rem EDE.	Undetermined**	WHC 1994a

* The probability shown for these scenarios is the occurrence of a DBE, however, the presence of a DBE does not necessarily mean the accident would occur. The worst case scenario involves a DBE triggering these two accidents as well as rupturing the HVAC recirculation duct. While it is not accurate to add the human health effects from each scenario, the consequences would be fairly similar to those discussed for the breach of the recirculation duct.

** In the absence of safety features, the most common mechanism for this accident is human error (e.g., vehicular collision). It is also possible that a DBE might result in a breach.

Accidents occurring during sluicing operations involving environmental releases of the tank waste to the atmosphere or soil column would result in the greatest impacts. An atmospheric accident would involve either a spray leak in a valve pit, an unfiltered release through a breach in the recirculation duct of the heating, ventilation, and air conditioning (HVAC) system leading to a radioactive release, or a transfer line break. A soil column accident would involve a breach of containment in the tank, leading to a spill of the liquid component of Tank C-106, which is not held up in either the sludge or hardened waste.

Many of the accident scenarios assume that releases occur for a prolonged duration. During the sluicing phase of the project, when the pumps are running and the waste is being retrieved, trained personnel would be present. The presence of these workers would minimize the duration of a release and restrict access to the release site. Additional precautions would be taken to protect on and offsite personnel in the event of an accident (such as stopping the pumps immediately, stabilizing and containing the release and evacuating onsite personnel as needed). Table 2 presents the accident scenarios, consequences, assumptions used, and administrative and design features in place which could lower the consequences of these accidents further.

Table 2.
Accident Assumptions and Consequence Reduction Features.

Accident Scenario	Consequence	Assumptions/Criteria	Means of Reducing Consequences
(1) Waste leak from Jumper or oscillator	1.6×10^4 rem EDE onsite 1.5×10^1 rem EDE onsite	External leak in valve pit 2-hour release 12-hour exposure Exposed worker(s) not wearing protective clothing	All valves provided with welded connections and double stem seals with leak detection devices in pits. Coverblocks sealed to the greatest extent possible. Interlock controls would shut down system when leak detection devices identify a leak. Visual monitors used to detect leaks in pump pits. Leak would be identified and personnel evacuated before 12 hours. Workers within the 241-C Tank Farm will be wearing protective clothing at all times and possibly respiratory equipment.
(2) Waste transfer line leak	1.0×10^4 rem EDE offsite 1.9×10^1 rem EDE onsite	The DBE occurs during the period the pumps are operating and the transfer lines are full Line break occurs at the low point of the line and 10 percent of the waste pools above ground Exposed worker(s) not wearing protective clothing Pool forms and remote investigated to calculate dose	Trained workers would always be present during shutoff operations and would be able to shut down the system after a DBE and evaluate the integrity of the lines. Solenoid switch would shut off shutoff operation. This point of the line would be buried 3 feet below grade, which would reduce the amount that could pool above ground. Workers in the 241-C Tank Farm (the hypothesized location for this accident) would be wearing protective clothing and respiratory equipment as required. After the release is detected, the area around the release would be controlled for personnel access and the spill stabilized to prevent airborne releases.
(3) Tank rupture due to a DBE	Potential large-scale release to the environment	DBE occurs during the early stage of shutoff, however, this accident could occur regardless of this project and is not specific to this project	A release would be possible whether shutoff is completed or not. Shutoff would remove the waste from Tank C-106 and eliminate the potential of a release from contained storage.
(4) Tank leak from shutoff	150,000 liters (40,000 gallons) released	Shutters cause leak or open existing plugged leak Leak occurs early during shutoff Leak detection devices fail	Shutters installed with controls to prevent them from hitting the tank walls. Shutoff would start from the center of the tank and leave the area around the tank walls until the end of the operation. Flow meters and a running material balance would be able to detect a leak when approximately 30,000 liters (8,000 gallons) are removed from the closed system.
(5) Restructuring line breach	5.2×10^4 rem EDE offsite 5.0×10^1 rem EDE onsite	Assumed that the accident occurs during shutoff operation Release not detected for one hour Onsite populations exposed to plume which exists after one hour release Onsite workers not wearing protective clothing	The probability of the accident (either vehicle collision or DBE) occurring during normal operations (estimated 6 months) is remote. A collision would result in the stoppage of shutoff operations and alarm switches would shut off shutoff operation (and the ventilation system) after the DBE. An accident would lead to evacuation of onsite workers not wearing protective clothing. Since the HVAC system is within the 241-C Tank Farm, all workers would be wearing protective clothing and respiratory equipment as needed.

For the accident scenarios, the offsite population is defined as the 115,000 people located within 80 kilometers (50 miles) of the release point in a southwesterly direction. The uninvolved workers (numbered at 1,630) are defined as personnel in the area greater than 100 meters (328 feet) to the south of the release point. Onsite health effects in terms of LCFs are presented for the uninvolved worker only. The risk to the directly involved worker (those workers directly involved with the proposed action, which may or may not be within the 100 meters [328 feet]) is highly dependant upon the worker's specific location, meteorological conditions, and nature of the accident. All of these circumstances could either increase or mitigate the severity of the consequences. Therefore, no quantification of risk to the directly involved worker is available; however, it is assumed that the directly involved worker could receive a substantially higher dose given the proper conditions.

Accident consequences are evaluated in terms of human health effects from radiological exposure. Nonradiological hazards, during normal sluicing operations, would be controlled by strict adherence to the contractor guidelines dealing with industrial safety (WHC-CM-4-3). Potential nonradiological hazards encountered during postulated accidental releases would be controlled by adherence to emergency procedures to be written prior to the initiation of the sluicing operation. These emergency procedures would be based upon analyses to be performed as part of future safety documentation. The Preliminary Safety Evaluation (WHC 1994a) examined the chemical constituents in Tank C-106, and indicate that toxic chemicals would not be available for release from the various accident scenarios in large quantities.

Waste Leak From Jumper or Connector. The first scenario considered was a waste leak from a jumper or a connector in a pump pit. Equipment in a pump pit would include valves that were provided with welded connections and double stem seals. Although the system would have been leak tested before operation, it is postulated for this scenario that an external leak could develop in the valve pit. Leakage, in the form of a spray in a valve pit, may result in an atomizing (spray) leak and release of waste material from improperly sealed openings in the pit covers which allow monitoring equipment to access the pump pit. From such a leak at 12.7 kilograms per-square-centimeter (180 pounds per-square-inch) and for a duration of two hours, an aerosol capacity of 10 milligrams per cubic meter (1.0×10^{-3} pounds per cubic feet) of transportable, respirable liquid aerosol equivalent to 3.0×10^2 liters (2.1×10^2 gallons) would be generated (WHC 1994a).

The mitigating feature of administrative controls (i.e., lock and tag procedures), which would ensure that the pit covers are always in place during waste transfer operations would reduce the consequences of a spray leak to the atmosphere to much lower levels than might occur in the absence of pit covers in the pump pits (WHC 1994a). With pit covers in place, the dose to the offsite MEI is calculated to be 1.6×10^{-4} rem Effective Dose Equivalent (EDE), which is within the "low" category of radiological dose consequences (WHC-CM-4-46). Uninvolved workers could be exposed to 1.5×10^{-1} rem EDE, also in the "low" category. Additional administrative controls which would include sealing the pit cover openings and edges could lower these numbers substantially. While there is no accurate method for calculating the dose received to the directly involved worker, it is conceivable that the dose could be somewhat greater. All doses in this section are considered to be a

50-year committed dose. With pit covers in place the chance of either the offsite or onsite MEI developing an LCF, which is calculated by multiplying the dose with the conversion factors of 4.0×10^{-4} (onsite) and 5.0×10^{-4} (offsite) (56 FR 23363), could be considered nonexistent (8.0×10^{-8} and 6.0×10^{-5} respectively). Even assuming that the directly involved worker receives a dose several orders of magnitude greater than that of the uninvolved worker (which can be considered extremely conservative), it is not likely that any adverse health effects would occur.

Waste Transfer Line Leak. This scenario assumes that both transfer lines (and both pipes comprising double containment) fail and the waste leaks at a rate of 1,324 liters (350 gallons) per minute from each line. It is further assumed that seismic switches located on the transfer lines would be activated and would shut down the pumps immediately. A duration of 10 seconds is used to estimate the time required for the pumps to stop completely and cease adding fluid to the transfer lines. Based upon this 10 second duration, an estimated 10,500 liters (2,800 gallons) could be released to the soil column. Due to the fact that the release is below grade and covered by an earthen berm, only a small amount of this total spill volume would pool above ground and affect human health. The majority of the waste would migrate downward and laterally from point of origin. Only a small percentage of the waste that pools on the surface would be in a condition to be considered as a possible source term which might impact human health. The mechanism for this accident has been determined to be a DBE, which has an annual probability of occurring (frequency) of 7.0×10^{-4} .

For the accident scenario dealing with a leak in the transfer line, the dose to the offsite MEI has been calculated to be 1.0×10^{-4} rem EDE, which is within the "low" criteria range for offsite populations. The onsite MEI has been calculated to receive a dose of 1.9×10^{-1} rem EDE, which also is within the "low" criteria range for uninvolved workers (WHC-CM-4-46). Based on the above numbers, the accident scenario dealing with a waste transfer line leak would result in a probability of 5.0×10^{-8} that the offsite MEI would develop an LCF and a probability of 7.6×10^{-4} for the onsite uninvolved worker. The total number of LCFs for the affected offsite population, determined to be the 115,000 persons residing within 80 kilometers (50 miles) southeast of the release site, has been determined to be 5.3×10^{-5} . This number was calculated by multiplying the offsite probability by a conversion factor of 2,500 (which can be calculated by dividing the collective dose to the affected offsite population by the dose to the offsite MEI) (Leach 1993). The uninvolved worker population (1,630) was calculated to have approximately 0.2 LCFs. This number was calculated by multiplying the volume of waste available on the surface as the source term, 1.0 liters (0.27 gallons), by the conversion factor of 0.16 LCFs per liter (0.6 LCFs per gallon). Given the proper conditions (i.e., the directly involved worker is in the immediate vicinity of the spill and the wind carries contamination toward that worker), the possibility exists for the directly involved worker to experience an adverse health effect, which might include genetic effects or even the occurrence of a fatal cancer.

Based upon the 10-second spill duration, and the soil characteristics of the area, it can be assumed that less than 28.3 cubic meters (1,000 cubic feet) of soil around the ruptured pipe would be contaminated and would need to be cleaned up. Radiation cleanup workers would wear proper clothing and respiratory protection when performing the remediation for this accident scenario. It is further assumed that five radiation cleanup workers would be employed for a period of one week. The absence of these seismic switches in the transfer lines could increase the amount of waste released into the environment by several orders of magnitude. The higher cost of eventual cleanup of a two hour spill duration, and the increased exposure likely to the cleanup workers, further justifies the presence of these switches.

For CY 1992, the average dose to radiation cleanup workers was 8 millirem per year (WHC 1993e). This number yields a collective dose to the five workers involved in the cleanup of the 10-second release scenario for a period of 1 week of 7.7×10^4 person-rem. The number of LCFs expected from this dose is 3.0×10^{-7} . In other words, an individual worker has less than one chance in one million of contracting an LCF as a result of cleanup activities.

The contaminated soil would be transported to existing onsite disposal or storage facilities. After the contaminated spill area is cleaned up, the spill area would be properly posted. Overall site remediation at and around the spill area would be included as a part of a Hanford Site operable unit cleanup.

Tank Rupture Due to a DBE. Another soil column accident would be the result of a seismic event which ruptures the tank. This accident scenario would be possible at any time and regardless of this specific waste transfer operation. Subsequently, a detailed discussion of this accident is not presented. The annual probability (frequency) of a DBE at the Hanford Site is 7.0×10^{-4} per year. While human health effects would probably not be a factor, the accident could involve the contamination of a large volume of soil depending upon when the accident occurs during the sluicing operation, which would require a significant cleanup operation. The total amount of waste in all forms in Tank C-106 is not expected to be greater than 750,000 liters (200,000 gallons) at any time, however, only that portion of the waste in a liquid form would contribute to the amount of waste released.

An accident of this magnitude could result in long-term health effects to the public if the contamination reached the groundwater and the groundwater was accessible to the public. However, the chance of contamination reaching the groundwater is remote since the most conservative release from Tank C-106 is estimated to be less than 662,000 liters (175,000 gallons), and the majority of radionuclides would be trapped in the top portion of the soil column. Cleanup of a leak of more than 375,000 liters (100,000 gallons) would likely be performed with the eventual cleanup of the tank farms and would be completed well before the waste reaches the groundwater. As has been mentioned, this scenario is possible for normal waste storage activities and is not exclusive to this action. In fact, this waste retrieval operation would reduce the risk of a DBE induced leak from Tank C-106 by removing the waste and storing it in a DST.

Tank Leak From Sluicing. Sluicing operations have the possibility of releasing liquid waste from the tank to the soil column. The probability of this happening is undetermined because of the lack of information concerning the condition of Tank C-106's bottom and sides. The most probable occurrence would involve the sluicers opening a plugged leak in the tank wall. The leak source term during sluicing would be any free-standing liquid present in the tank during the sluicing operation, the drainable interstitial liquid above the level of the leak point, and the sluicing stream as it impacts the tank wall. Based on historical leak rates of other SSTs, the actual leaked volume is expected to be on the order of a few cubic meters (several thousand gallons). However, the most conservative estimate has a release of up to 150,000 liters (40,000 gallons) (WHC 1993d). This estimate assumes that the leak occurs early in the sluicing operation, that leak detection devices and controls fail, sluicing operations proceed without these leak detection devices, the leak(s) occur at the bottom of the tank, and the remaining sludge does not plug these leaks. The size of any leaks would be limited by: (1) the ability to detect leaks, (2) administrative controls on liquid inventories, (3) the tendency of solids in the sludge to plug any leaks, and (4) the free liquid in the Tank C-106, is limited, and could be pumped out in a short time. The presence of flow meters on the transfer lines and material balance controls on Tank AY-102 would detect a leak when approximately 30,000 liters (8,000 gallons) are removed from the sluicing process by means of a leak somewhere in the closed-loop system.

Any postulated waste leak, upon reaching the soil, would be driven downward by the moisture recharge, rainfall and runoff, from the tank dome. Travel time for the first of the radioactive constituents in the waste to reach the aquifer is calculated to be about 60 years (WHC 1993d) (though most of the constituents would be held up in the top portion of the soil column and would take significantly longer to reach the aquifer), provided the amount leaked was small compared to the rate of recharge, and no preventative measures were taken to halt the migration. It has been shown that surface barriers are effective in limiting the migration of any tank leaks. Any contaminated soil could be recovered or treated after sluicing, if required, as part of the overall site closure activities under the Tri-Party Agreement milestone M-45-06. No immediate human health effects are anticipated from this accident; however, if left unchecked, the release would have the potential to contaminate a relatively small section of groundwater.

Recirculation Line Breach. It has been postulated that a mechanical accident (e.g., a vehicular collision) or a DBE (with a probability [frequency] of 7.0×10^{-4} per year) could result in a breach in the recirculation line of the ventilation system, leading to a release of radioactive air emissions. A DBE would pose a threat to normal tank waste storage activities; however, in this scenario, the DBE would damage the recirculation line installed by this project. Therefore, this DBE accident is specific to this project, and is evaluated in this section. For this scenario it is assumed that the recirculation duct has been breached and unfiltered ventilation flow passes through the stack, and that the failure is not detected for one hour (it should be emphasized that this duration is extremely conservative since engineered features would be designed to shut off HVAC system when a break occurs to any of its piping). Based on a vapor space capacity of 100 milligrams per cubic meter (1.3×10^{-2} pounds per cubic feet), approximately 0.146 liters (0.04 gallons) are released, leading to an

offsite dose calculation of 5.2×10^{-4} rem EDE to the MEI, which is within the "low" category, and an onsite dose of 5.0×10^{-1} rem EDE, which is within the "high" category (WHC 1994a). These numbers represent a probability of 2.6×10^{-7} that the offsite individual would develop an LCF, and 2.0×10^{-4} for the onsite population. Using the conversion factor mentioned in the transfer line leak scenario, an anticipated 2.0×10^{-4} LCFs would occur to the entire affected offsite population (identified as the 115,000 persons residing to the southeast) (Leach 1993). Based upon 0.146 liters (0.04 gallons) release volume, and the onsite population conversion factor of 0.16 LCFs per liter (0.6 LCFs per gallon), no LCFs to the uninvolved workers would be expected (the actual number being 0.02 LCFs for the uninvolved worker population of 1,630). It is not likely that any adverse health effects would occur to the directly involved workers.

This scenario is considered the worst case accident when examined separately. It is possible that a DBE could trigger not only a recirculation duct break, but also a rupture of the waste transfer lines and a breach of tank confinement in Tank C-106. If this were to occur, the health consequences to on- and offsite populations would be close to, but somewhat higher than, the health effects presented for this scenario. In addition, the potential for large scale soil contamination, and possibly groundwater contamination, would exist. As noted earlier, however, the impacts from a DBE-initiated leak are not specific to this proposed action, but could occur for normal waste storage operations.

5.3 Waste Compatibility

The transfer of waste from Tank C-106 to Tank AY-102 raises the issue of waste compatibility. The *Chemical Compatibility of Tank Waste in 241-C-106, 241-AY-101 and 241-AY-102* (WHC 1994d) evaluated waste compatibility (WHC 1994a), and stated that using Tank AY-102 would not result in potentially dangerous situations. This document verifies that no chemical compatibility safety issue currently understood or perceived to exist would be adversely impacted by the proposed waste transfer operation. Additionally, the waste in Tank AY-102, after sluicing, would not be in a condition that precludes future treatment options.

Specifically, the compatibility safety issues addressed in this waste compatibility evaluation are criticality, energetics, corrosivity, and flammable gas accumulation. It was determined that criticality was not an issue based on analytical data. A criticality is defined as a self-sustaining or divergent neutron chain-reaction that has the potential to release large amounts of energy. Plutonium concentrations were determined to be so minimal as to be impossible to support a criticality prior to, or as a result of, waste transfers. Transfer of the fissile material contents, namely plutonium, from Tank C-106 to the receiving tank fully complies with, and does not exceed current criticality safety evaluation report limits. A waste characterization report (WHC 1988) provided analysis of a core sample from Tank C-106. The plutonium concentration is given as 7.1×10^{-2} grams per liter (9.0×10^{-3} ounces per gallon), a value less than 8 percent of the Criticality Prevention Specification (CPS) limit. The transfer of this waste to Tank AY-102 would satisfy limits provided by the applicable CPS. Further analysis of this criticality issue, which supports the

above conclusion, is addressed in the *Criticality Safety of Single Shell Waste Storage Tanks* (WHC 1994e).

The analytical data also indicated that there is minimal organic carbon contained in the wastes of Tanks C-106, AY-102, and AY-101. Furthermore, if the organic carbon is conservatively assumed to be entirely in the form of Sodium Acetate, then there is still greater than twice the needed water to suppress the limiting exothermic reaction that might be postulated. This provides assurance that no propagating exothermic reaction is sustainable before, during, or after combining these wastes as described in the proposed action. Further, the concentrations of hydroxide, nitrate and nitrite, as well as the average temperature (all parameters affecting corrosion of the tank walls) would continue to be well within acceptable limits.

Finally, the existing and resultant specific gravities of the wastes would not result in exceeding specifications for placing the tank(s) on the flammable gas "Watchlist." The specific gravity provides an indication of the capability for retention of flammable gases (e.g., hydrogen) within the waste. While the waste compatibility evaluation indicates that hydrogen buildup would not be a problem, further safety analysis will evaluate this issue. It is possible that the initial sluicing fluid to be used may be supplemented with a caustic solution (sodium hydroxide) to ensure that flammable gas generation is not a problem. It is proposed to utilize the existing airlift recirculators in Tank AY-102 to agitate the waste after the sluicing operation is completed, if needed. This agitation would result in the constant release of potentially flammable gases, and the prevention of a surface layer in the waste that could trap these gases. If the possibility arises for hydrogen accumulation, hydrogen monitoring equipment may be installed. In addition, the introduction of the initial sluicing fluid to Tank C-106 would maintain a large margin of safety, and would not result in compromise of chemical compatibility between the sluicing fluid and the waste in Tank C-106 (WHC 1994a).

Certain accidents that were not analyzed in this Environmental Assessment have been analyzed by other tank farm facilities. These accidents include tank dome failure due to exceeded weight limits, tank bottom penetration by dropped equipment, and riser damage due to excavation and/or construction activities. These accidents were found to have a smaller risk, where risk equals the product of probability and consequence, than the analyzed accidents. In other words, either the probability of the event occurring was outside the realm of reasonableness or the consequences were not considered substantial enough to warrant discussion.

5.4 Analysis of Alternatives

5.4.1 Analysis of Alternative Waste Retrieval Methods

While all of the alternatives presented in Section 3.0 were designed to retrieve the waste in Tank C-106, they often involved additional environmental impacts. Several of these

alternatives had greater impacts than the proposed action, while others posed less of a threat to the environment, but involved substantially more design or construction costs which likely would mean failure to meet the October 1996 targeted start time.

The Once Through--No Recycle, Limited Mixer Pump, and Internal Recirculation Alternative would utilize a tanker truck to provide the sluicing medium to mobilize the solids in Tank C-106. Since none of the slurry deposited in the receiver tank would be recycled, the space requirements for Tank C-106's waste would be greater than the proposed action or the Batch Transfer Alternative. This additional waste would add to the total amount of waste which would eventually have to be treated, and does not support the waste minimization policy practiced at the Hanford Site.

Two of the alternatives, the Recirculate Within a SST Via Mixer Pump, and the Center Pivot Dredge Alternatives, both pose greater environmental risks than the proposed action. The Recirculate Within a SST Via Mixer Pump Alternative would introduce potentially more heat than the proposed action from the increased mixing and agitation of Tank C-106's waste. This alternative also would increase the environmental risk, relative to the proposed action, due to possible damage to the tank from the mixing pump outlet spray impinging on the tank walls, and maintain a much higher liquid inventory in the tank. In addition, this alternative would involve installing a new riser to the tank, and would require a longer design and testing period. The Center Pivot Dredge Alternative raises issues on worker safety due to the need for the construction of a 1.5-meter (5-foot) opening necessary to allow the dredging equipment access to the waste. This would lead to the possibility of a higher exposure to workers both during the creation of this opening and during operation of the dredging equipment. There also are concerns on exceeding tank dome weight limits with this alternative. Other negative factors include a high cost to implement; greatest design complexity compared to alternatives; and the amount of equipment to be decontaminated and decommissioned is larger than the other alternative.

The Hydraulic Mining Alternative would have the potential for the greatest waste minimization of the alternatives, but would be much more complex than the proposed actions. As this is an unproven technology, unlike the proposed action which has been used extensively in the past at the Hanford Site, the time required to develop and test this method would probably lead to failure in meeting the accelerated or Tri-Party Agreement timeframe. While the waste minimization aspects make this alternative attractive, the time required to design and implement this alternative makes this method unacceptable.

The Batch Transfer Alternative would utilize a temporary receiver tank which would require additional ventilation systems, and more waste transfer line jumpers, which would increase the probability of a waste leak from a failed jumper. The temporary receiver tank would be an additional source term that would have the possibility for release in the event of an accident. Due to this alternative's increased complexity created by the additional engineering requirements of the accumulation tank, an agitation system, and the additional pumps required to pump waste from the accumulation tank to Tank AY-102 and supernatant from the accumulation tank to Tank C-106, it is estimated to extend the project duration by 2 to 3 years and would mean the probable failure of the October 1996 start date. Further, this waste retrieval operation is estimated to entail a higher cost (as much as \$10 million)

than the proposed action, and may require more detailed and extensive environmental permitting due to the construction of the new accumulation tank.

5.4.2 Analysis of the No-Action Alternative

Under this alternative, the high-heat waste would remain in Tank C-106 and continue to generate sufficient heat to require active cooling. The primary cooling method would be the continued addition of cooling water, however, alternative means might be available, such as an air chiller or a combination of an air chiller and a sprinkler system. Regardless of the method used to cool the waste, the threat of a structural failure of the tank would remain, and increase over time. The probability of the DBE, which could lead to a breach in tank confinement, would continue to exist. The waste would continue to be stored in a tank which is considered past its design life and more susceptible to release than if it were stored in the newer DST.

Using the same conservative assumptions which were presented in the accident scenario dealing with a tank leak created by sluicing operations (i.e., leak detection devices and controls fail, the leaks occur at the bottom of the tank, and the remaining sludge does not plug the leak sites), the possibility exists for a large leak to develop. If Tank C-106's waste is not retrieved and remains in the tank for an extended duration, the likelihood of the tank failing, and a leak occurring, becomes greater. The presence of leaks in other SSTs at the Hanford Site indicate that it is only a matter of time before these tanks lose their integrity.

Tank C-106 would continue to remain on the safety "Watchlist," and continue to pose a risk to the environment. In addition, the Tri-Party Agreement milestones for the retrieval of Tank C-106's waste, and demonstration of a waste retrieval technology, would not be met.

5.5 Cumulative Impacts

The potential impacts from the proposed action are not expected to contribute substantially to the cumulative impacts of tank farm operations. In fact, because the high-heat waste would be removed from Tank C-106, which is at the end of its design life, it is expected that there would be a decrease in the overall risk to the environment.

Radioactive materials and nonradioactive chemicals are handled routinely on a daily basis throughout the Hanford Site. Standard Operating Procedures, and administrative controls, would provide sufficient personnel protection such that exposure to radiological and chemical materials would be kept below DOE guidelines, and within the policy of ALARA. The sluicing and waste transfer operations would not have a substantial cumulative effect on day-to-day operations on the Hanford Site with respect to worker exposure. The incremental impact from handling radioactive or nonradioactive materials that would result from the proposed action would be very small, and when added to the impacts from existing day-to-day operations on the Hanford Site and surrounding community, the total impact would remain small.

While sluicing operations would release some radionuclides, the proposed action is not expected to substantially increase the amount of radioactivity released from total Hanford Site operations. DOE limits the dose received to an individual worker to 5,000 millirem per year. In 1992, the offsite MEI was exposed to 3.7×10^{-3} millirem EDE from total air emissions (DOE-RL 1993), well below allowable limits (10 millirem to the public from airborne sources) set by state and federal regulations (WAC 246-247). The potential dose to the hypothetical offsite MEI during CY 1993 from Hanford Site operations were 3.0×10^{-2} millirem (PNL 1994b). The potential dose to the population within 80 kilometers (50 miles), established at 380,000 persons, from 1993 operations was 0.4 person-rem. The 1993 average dose to the population was 1.0×10^{-3} millirem per person.

Waste generation resulting from the proposed activity is not expected to be a substantial quantity compared to annual Hanford Site waste generation. For example, small quantities of low-concentration hazardous waste (e.g., solvents, cleaning agents) could be generated as a result of performing the proposed activities. These materials would be managed and disposed of in accordance with applicable federal and state regulations. Liquid waste generated from decontamination of equipment and the transfer lines is expected to be less than 26,000 liters (7,000 gallons), which could be easily stored in Tank AY-102. This project could potentially result in the creation of approximately 2,000,000 liters (500,000 gallons) of additional liquid waste if an uncontaminated fluid is used as the sluicing agent. While this would represent an increase in the amount of waste to be stored and treated at the Hanford Site, it is within current tank farm capabilities and in accordance with current waste management strategies (i.e., it could be sent to the evaporator for volumetric reduction). Radioactive waste, radioactively contaminated equipment, and mixed waste would be appropriately packaged, stored, and/or disposed of at existing treatment, storage, and/or disposal units on the Hanford Site. It is estimated that this project would produce an average of 62 cubic meters (2,200 cubic feet) of low-level and low-level mixed waste per year. This waste would be sent to either the Hanford Central Waste Storage Facility or the low-level burial grounds. This number represents only a minor amount of waste received at these facilities in the course of a year and would not substantially impact their operation or design life. The recorded total volume of waste received in the 200 Areas for storage in CY 1991 was approximately 6,028 cubic meters (213,000 cubic feet) (PNL 1992).

5.6 Environmental Justice

Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*, requires that Federal agencies identify and address, as appropriate, disproportionately high and adverse human health or environmental effects of their programs and activities on minority and low-income populations. DOE is in the process of developing official guidance on the implementation of the Executive Order. However, the analysis in this EA indicates that there would be minimal impacts to both the offsite population and potential workforce during the proposed action, under both routine and accident conditions. Therefore, it is not expected that there would be any disproportionate impacts to any minority or low-income portion of the community.

6.0 Permits and Regulatory Requirements

It is the policy of DOE to carry out its operations in compliance with all applicable federal and state laws and regulations, Presidential Executive Orders, and DOE orders. Environmental regulatory authority over the Hanford Site is vested both in federal agencies, primarily the U.S. Environmental Protection Agency (EPA), and in State of Washington agencies, primarily Ecology.

The SSTs are being operated under interim status as treatment and storage units under WAC 173-303. A dangerous waste closure/postclosure plan would be submitted to Ecology for closure of the SSTs (Ecology et al. 1993). Specific requirements under RCRA include revisions to the Part A permits for both the SST and DST Systems, and revisions to the Part B permit for the DST System (WHC 1993f).

Notification and approval from the DOH would be required because of the potential increase in radionuclide air emissions. Additionally, a National Emissions Standards for Hazardous Air Pollutants Permit is required by the EPA (40 CFR 61), and an approval for Toxic Air Pollutants is required by Ecology. All of these approvals would be obtained before the start of construction for this activity. Phase I and Phase II CAA Permit Applications would have to be prepared and submitted to Ecology, the DOH, and the EPA. Phase I applications deal with non-HVAC systems, while Phase II applications deal specifically with HVAC systems.

The project would not be subject to the "National Primary and Secondary Ambient Air Quality Standards" (40 CFR 50), the federal new source review program, or emission limitations in an air quality control region. The project would conform to the State Implementation Plan for air quality.

A permit would be required from the DOH for the installation of the sanitary catch tank to be buried at the control trailer if this option is chosen.

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7.0 Organizations Consulted

Prior to approval of this document, a draft version was sent to Ecology, the Yakama Indian Nation, the Confederated Tribes of the Umatilla Indian Reservation, the Nez Perce Tribe, and the Wanapum. Comments were received from the Yakama Indian Nation and were considered in the preparation of this document. Appendix C contains the Yakama Indian Nation's comments and the DOE responses.

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8.0 References

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- 40 CFR 61, 1992, "National Emission Standards for Hazardous Air Pollutants," *Code of Federal Regulations*, as amended.
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Figures

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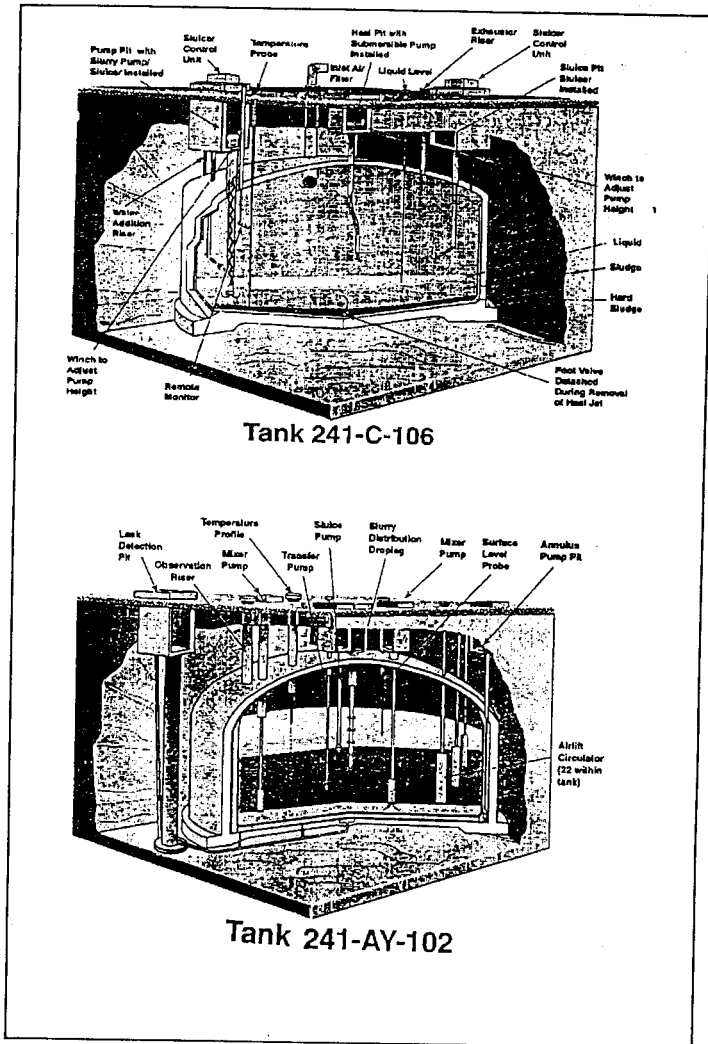


Figure 2.
Tank 241-C-106 and Tank 241-AY-102 Configuration.

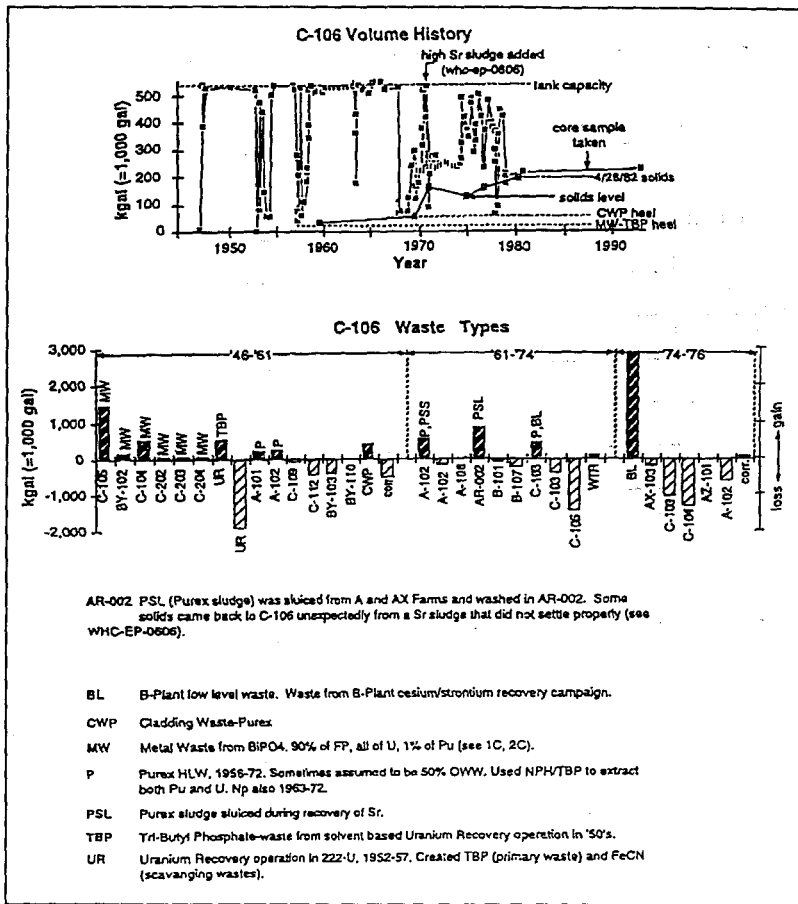


Figure 3. Tank 241-C-106 Volume History.

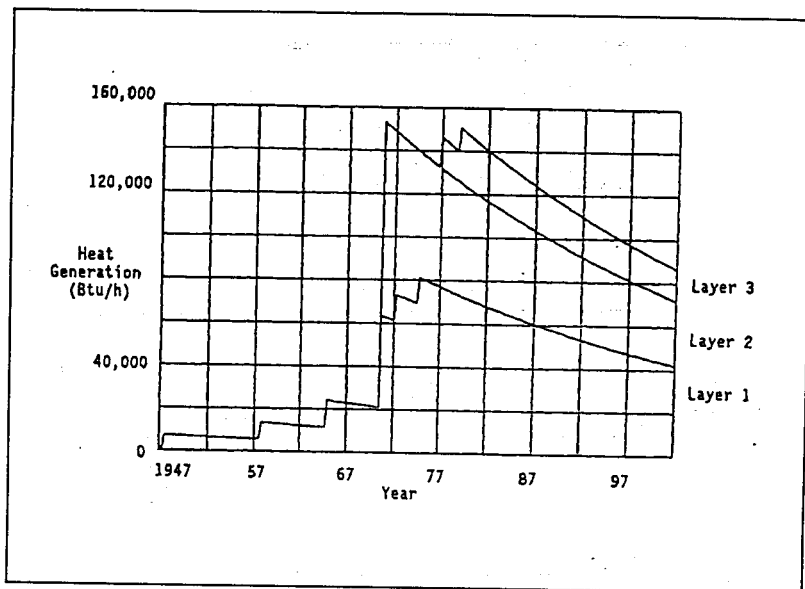


Figure 4. Tank 241-C-106 Heat Generation by Layer.

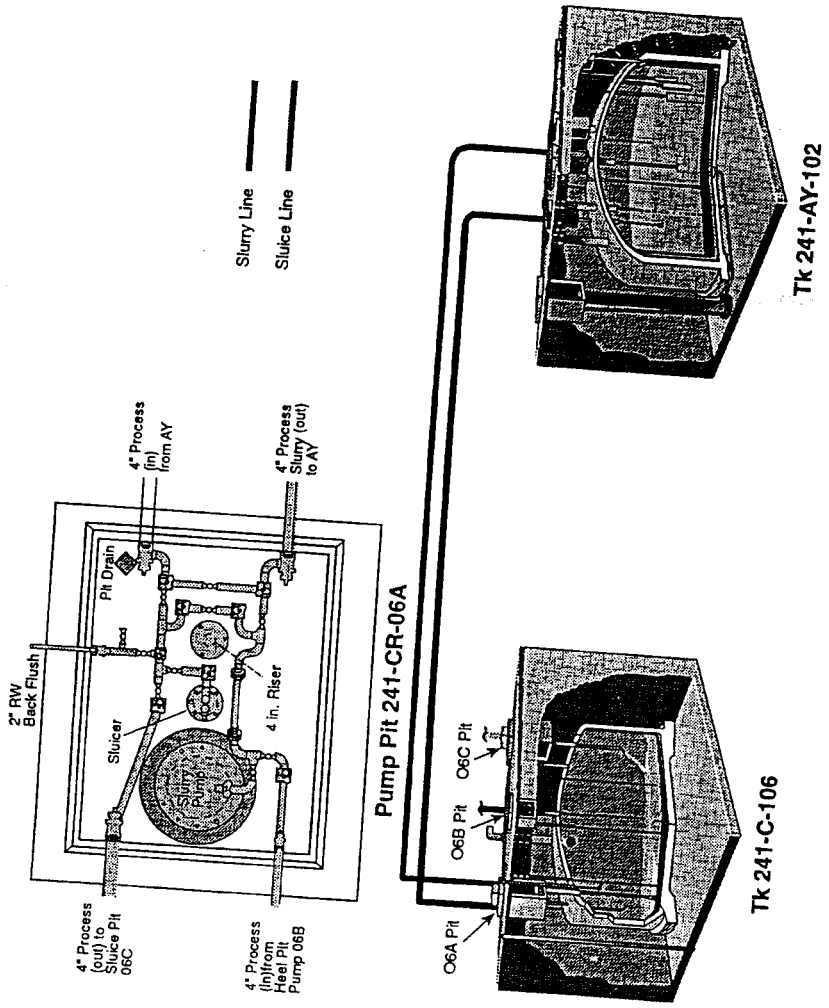


Figure 5. Tank-To-Tank Sluicing.

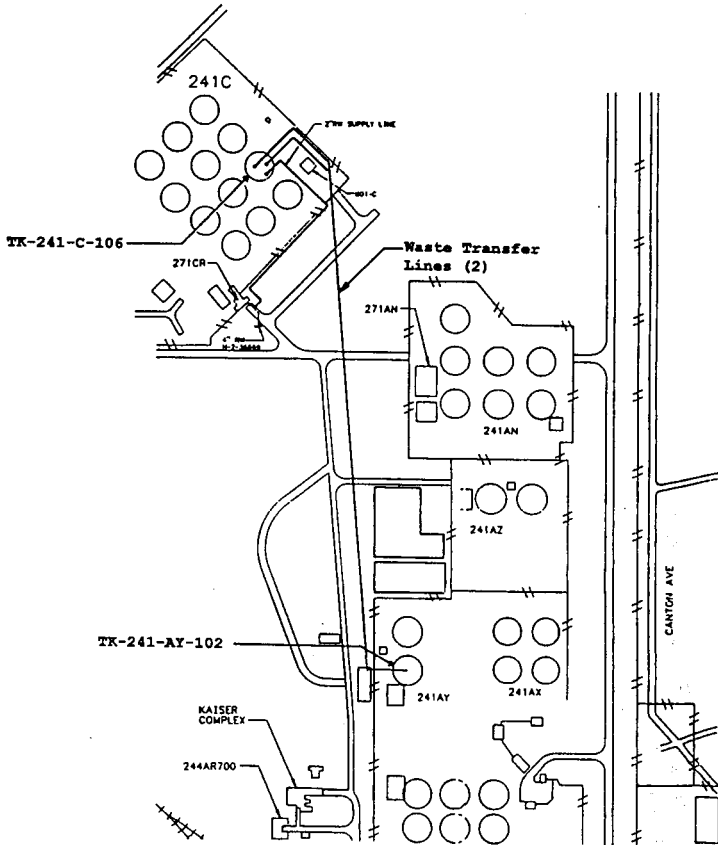


Figure 6.
Proposed Location of Waste Transfer Lines.

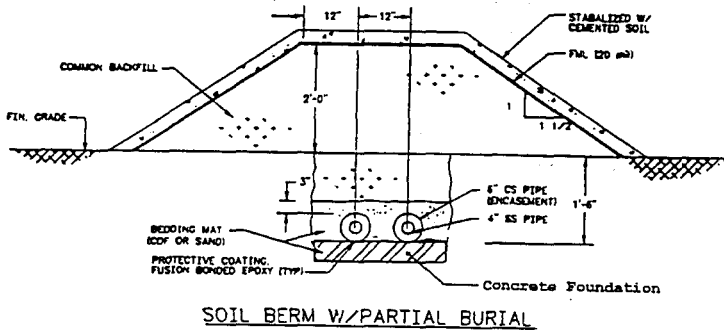


Figure 7.
Proposed Pipeline Configuration.

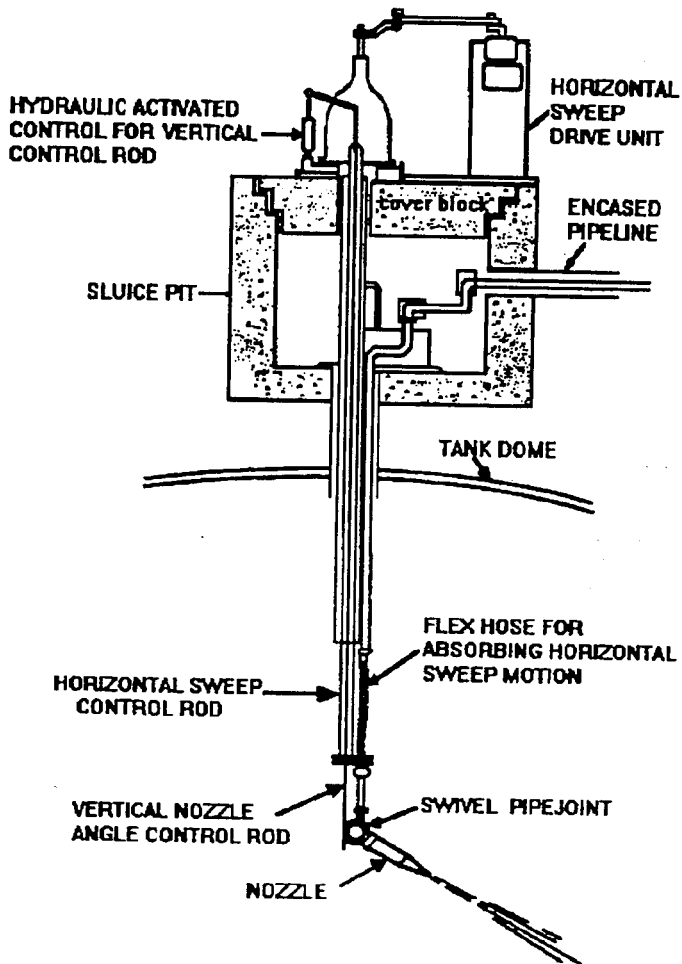


Figure 8.
Typical Sluicer Configuration.

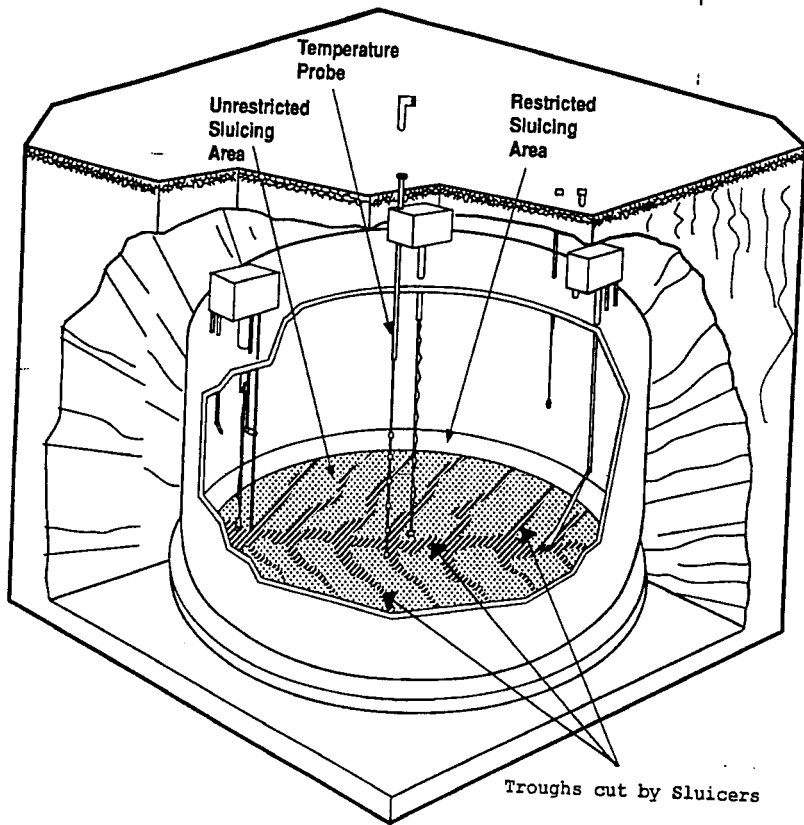


Figure 9.
Tank 241-C-106 Sluicing Features.

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Appendix A
Cultural Resources Review
(HCRL #93-200-111)

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**Battelle**Pacific Northwest Laboratories
Battelle Boulevard
P.O. Box 999
Richland, Washington 99352
Telephone (509)

372-1791

August 9, 1993

*No Known Cultural Resources*Mr. Warren Rued
Westinghouse Hanford Company
Restoration and Remediation
P. O. Box 1970/H6-26
Richland, WA 99352**CULTURAL RESOURCES REVIEW OF PROJECT W-320, TANK 241-C-106 SLUICING. HCRC #93-200-111.**

Dear Warren:

In response to your request received August 4, 1993, staff of the Hanford Cultural Resources Laboratory (HCRL) conducted a cultural resources review of the subject project, located in the 200 Area of the Hanford Site. According to the information that you supplied, the project entails sluicing Tank 241-C-106 to remove solid waste and transferring the waste to Tank 241-AY-102. The sluicing and transfer will require two transfer pipes to be installed above ground between the two tanks, except where the pipes meet existing roadways when the depth of burial will not exceed six ft, and the installation of a double-wide trailer.

Our literature and records review shows that project is located in an area that has been highly disturbed by previous construction. It is very unlikely that any intact cultural materials would exist in such disturbed ground. Survey and monitoring by an archaeologist are not necessary.

It is the finding of the HCRL staff that there are no known cultural resources or historic properties within the project area. The workers, however, must be directed to watch for cultural materials (e.g., bones, artifacts) during excavations. If any are encountered, work in the vicinity of the discovery must stop until an HCRL archaeologist has been notified, assessed the significance of the find, and, if necessary, arranged for mitigation of the impacts to the find. This is a Class III case, defined as a project that involves new construction in a disturbed, low-sensitivity area. Please notify us if changes to the project location or dimensions are anticipated.

A copy of this letter has been sent to Charles Pasternak, DOE, Richland Operations Office, as official documentation. If you have any questions, please call Beth Crist, AScl Corporation, at 372-1791. Please use the HCRC# above for any future correspondence concerning this project.

Very truly yours,

M. K. Wright
Scientist
Cultural Resources Projectcc: C. R. Pasternak, RL (2)
Fila/LB

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Appendix B
Ecological Survey
(#93-200-40)

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Environmental Assessment
for the
Remediation of
the
Hanford Site

**Westinghouse
Hanford Company**
**Internal
Memo**


From: Environmental Technology and Assessment
 Phone: 376-9956 H4-14
 Date: August 16, 1993
 Subject: SURVEY NUMBER 93-200-40

25320-93-126

To: W. J. Rued H6-26

cc: L. L. Cadwell P7-54
 K. A. Gano X0-21
 A. R. Johnson H6-30
 D. S. Landeen H4-14
 M. R. Sackschewsky H4-14
 J. C. Sonnichsen H4-14
 S. W. Seiler B4-64
 R. S. Weeks H6-26
 S. Weiss H6-02
 DSL File/LB

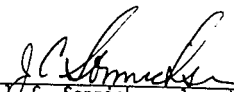
This letter is in response to the request for a biological assessment in support of the transfer line between 241-C tank farm and the 241-AY tank farm as part of Project W-320, "Past Practice Sluicing of Tank 241-C-106." Although no biological surveys have been conducted in the near vicinity during 1993, no adverse impacts to any plant or animal species of concern are expected to occur because the proposed routing of the transfer line is adjacent to established roadways and through highly disturbed areas. Most of this area is currently under vegetation management.



M. R. Sackschewsky
 Biological Sciences Team
 Senior Scientist

mjm

CONCURRENCE:



J. C. Sonnichsen Jr., Manager
 Environmental Technology
 and Assessment

Date: 8/16/93

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Appendix C

Yakama Indian Nation's Comments and DOE Responses

NOTE: Finalization of the EA may have resulted in changes to the specific pages/paragraphs referred to in the DOE response letter to the Yakama Indian Nation.

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Confederated Tribes and Bands
of the Yakima Indian Nation

Established by the
Treaty of June 9, 1855

February 24, 1994

COMMITTEE CONTROL
PHONE 5-8537
CONTROL NO.
940890.2
ASSIGNED TO
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DISTRIBUTION
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PSL

Mr. John Wagoner, Manager
Richland Operations Office
Department of Energy
P.O. Box 550 A7-50
Richland, WA 99352

Subject: ENVIRONMENTAL ASSESSMENT FOR TANK 241-C-106 PAST-PRACTICE
SLUICING WASTE RETRIEVAL; COMMENTS ON--

Dear Mr. Wagoner:

Department of Energy Richland Operations letter 94-PRJ-006 from Mr. Duniagon of your staff requested comments on the subject environmental assessment (EA).

We support the action to expedite the remediation of Tank C-106; however, we are concerned with the potential environmental impacts associated with the evolution and recommend that thorough engineering evaluations be accomplished and reported by means of the subject EA.

We consider that, in general, EA's should be used more consistently as a project controlling document to assure comprehensive engineering evaluations for projects are accomplished and potential impacts properly identified and quantified.

This type of information is necessary to rationally reach conclusions about the conceptual design of a project and impact mitigation measures. It is consistent with Mr. Grumbly's recent initiative to improve the front-end planning as a means of reducing project costs.

Comments concerning the subject EA for Tank C-106 reflecting this consideration are contained in the Attachment to this letter.

Sincerely,

Russell Jim, Manager
Environmental Restoration/Waste Management Program
Yakama Indian Nation
P. O. Box 151
Toppenish, WA 98948

ATTACHMENT: Comments on Environmental Assessment Tank 241-C-106
Past-Practice Sluicing Waste Retrieval DOE/EA/XXXX
(see next page for distribution)

RECEIVED

RI Commitment Control

MAR 02 1994

MAR 01 1994

Ac# 949626

DOE-RI/CC

Richland Operations Office

Post Office Box 151, Fort Road, Toppenish, WA 98948 (509) 865-5121
194-PRJ-002

H.B

cc: K. Clarke, DOE/RL
M. Riveland, WA Ecol.
G. Emison, U.S. EPA Reg. 10
T. Grumbly, DOE/EM
Washington Gov. M. Lowry
U. S. Congressman J. Inslee
U. S. Senator P. Murray

**ATTACHMENT: Comments on Environmental Assessment Tank 241-C-106
Past-Practice Sluicing Waste Retrieval DOE/EA/XXXX**

Comments prepared by J.R. Brodeur, P.E.

General Comment:

USE OF EA'S TO IDENTIFY ENGINEERING SCOPE AND ENVIRONMENTAL ISSUES-

We consider that Environmental Assessments (EAs), including the subject EA, provide a primary means of identifying issues and concerns about technical aspects of a project. However, the subject (EA) does not adequately address engineering concerns associated with potential environmental impacts of the subject project.

Our concerns reflect a potential for significant environmental impacts, such as leaks or spills resulting from the sluicing operation, and we consider these concerns should be addressed and resolved. Resolution of some of those concerns may be the responsibility of the various engineering functions of the project and may not necessarily be resolved in the EA; but the EA should provide the formal vehicle to commit to addressing the concerns and should respectively identify or reference the appropriate engineering documents that are planned or completed.

It appears that there is inadequate preliminary engineering assessment of the subject sluicing project to comprehensively scope technical issues and establish conceptual designs. We note that Mr. Grumbly, in connection with the recent stand down, identified the need to perform more comprehensive engineering at the initial stages of major projects such as this one. We agree that comprehensive engineering in the initial stages of various DOE projects has been a root cause of cost over-runs and inefficient operations. In it's current form, the EA falls short of providing a true assessment of the impacts to the environment. Furthermore, it appears to be based on a collection of disorganized, uncoordinated documents that use inconsistent design and operational criteria. The EA should be revised to correct the deficiencies identified below.

SPECIFIC COMMENTS:

1. LEAK EVALUATION, OVER-FILLING TANK-AY-102--Page 2-1, 3rd par.-- This paragraph states that C-106 contains 173,000 gal. of top layer sludge of which at least 75% is to be removed (129,750 gal.) to AY-102 in the sluicing operation. However, according to WHC-EP-0182-64 (TF Surveillance and Waste Status), Tank AY-102 only has 131,000 gal. of space available. This leaves only a 1250 gal. difference. Additionally, both the EA and the functional design criteria (FDC) (WHC-SD-W320-FDC-001 Rev.1) indicate that the transfer lines will be flushed after completion of the sluicing operation.

We assumed from the description of operations in the EA that pumping of liquid from C-106 will be accomplished at the same rate at which sluicing liquid is pumped into C-106 (350 gpm). Therefore, after pumping 75% of the liquid from C-106 there would only be a maximum of 3.5 minutes before the pump must be turned off to assure AY-102 is not filled beyond its capacity.

This will require careful monitoring with adequate instrumentation and operational controls to prevent spills and overflowing tank AY-102. In this regard monitoring criteria should be specified in the EA, and the EA should assess the environmental impact of leak or spill considering the capabilities of the instrumentation.

In summary, our concern is that tank AY-102 may be filled beyond design capacity, resulting in an environmental impact due to a release from the first shell of the double shell tank. We consider that additional engineering is required to address and prevent this scenario.

The EA should consider the realistic impact of overflowing AY-102, and such a risk should be minimized by adequate process design, instrumentation and automatic pump controls.

2. OPERATIONAL CONTROLS TO PREVENT LEAKS/SPILLS--

The EA is not clear about the amount of liquid that will be in Tank C-106 at any time during the sluicing operation. The functional design criteria (FDC), described in WHC-SD-W320-FDC-001, provide an upper limit of liquid in the tank at 79 inches (217,000 gal). However, this document a) does not indicate how the amount of liquid in the C-106 will be minimized; b) does not state what criteria will be used to decide when pumping from C-106 will occur; or c) does not indicate, if there will be any additional controls to minimize the liquid. Also, there is no explanation of the sequence of events relative to the pumping and sluicing operations in the EA, in the FDC, or in the procedural report (WHC-SD-WM-ES-234).

The following additional questions should be resolved by the engineering documents justifying the subject operation: a) Will the existing liquid in the tank be pumped prior to introduction of the sluicing liquid? b) Will the sluicing liquid be pumped from C-106 during the sluicing operation? c) Will there be a significant fluctuation in the liquid level? Appropriate operational limits should be specified in the procedures.

The EA should provide a clear statement as to the maximum volume of liquid to be placed in tank C-106 at any time, and it should clearly indicate the sequence of the pumping and sluicing operations. These process design data should be used as input parameters in the tank leak engineering study (WHC-SD-WM-ES-218). Currently, that study assesses tank volume criteria that are inconsistent with the FDC.

A primary concern is that leaving a large amount of liquid in C-106 during the sluicing operations could promote a leak from the tank and result in an environmental impact. The EA should consider such an impact and assess this impact. (The significant cooling anticipated by the removal of the sludge will cause thermal contraction of the tank that could lead to tank failure.)

3a. LEAK DETECTION CAPABILITY--

As suggested by the comments above, questions remain about the current ability to detect leaks and the resulting environmental impacts from undetected leaks. The tank leak engineering assessment (WHC-SD-WM-ES-218) postulates a low volume leak, even though, as a result of poor precision leak detection instrumentation, a high volume leak may go undetected,

Therefore, an engineering assessment of the Hanford single shell waste tank leak detection systems to be used in the sluicing operations should be completed and those data should be used to provide input to the tank leak engineering study. This, in turn should be referenced and used in the EA. Engineering evaluations of the leak detection systems that exist should be made public as background information.

The EA should provide a credible assessment of the maximum leak volume to compare with our estimate of 200,000 gal. (See comment 3b below) that could be released in the sluicing operation, and an evaluation should be made of various sluicing methods so as to minimize the chances of a leak from C-106.

3b. TANK INTEGRITY WITH SLUICING--Section 5, pp 5-7 & 5-8--

We have a major concern about the current integrity of Tank C-106; about the possibility that the sluicing operation will induce further leaks from the tank; about the inadequacy of the leak detection instrumentation; and about the inadequacy of the EA in assessing the impacts resulting from a leak.

The question about the current integrity of the tank has not been addressed in the EA. However, documents describing studies about possible tank leaks in the C-farm, specifically addressing possible leaks from C-106, have not been reviewed or referenced in the EA. Studies about the integrity of C-106 have not been completed (see recommendations section of WHC-SD-EN-TI-185). Specifically, there is contamination in the unsaturated zone on the north-west and east sides of this tank that is of unknown origin. Some of that contamination is deep in the unsaturated zone and is probably not from downward migration of surface contamination. Additional studies are required to identify the sources of that contamination. Such studies, together with a comprehensive assessment of the origin of the unsaturated zone contamination and the tank integrity should be completed. This study should include a review and analysis of all historical tank leak detection data.

We consider that the sluicing operation should not proceed without knowing if the tank is currently sound, if it has leaked in the past, if the operation will induce another leak, or if the sluicing operation could be performed with a minimal amount of free liquid in the tank to mitigate such a potential leak.

To evaluate the worst case scenario, the EA should assess the impacts resulting from a large leak (over 200,000 gal). In any case, adequate tank integrity characterization should be performed and sluicing operational controls should be put into place to minimize the possibility of a large leak.

4. LEAK DETECTION FOR TRANSFER LINES AND PUMP PITS--Page 2-3--
The last sentence states "Leak detection would be provided for the new transfer lines and pump pits." Since leak detection is critical to prevention of spills, considering the spill history at C farm, more detail concerning this issue is warranted in the EA. A more rigorous assessment of the possibility of a spill is needed. Such an assessment should identify the instrumentation required to assess a spill and evaluate the probability of a spill. This was not accomplished in the referenced Hazard Classification (WHC-SD-WM-HC-007). As a result, the real hazard associated with a spill is not determined, and the potential environmental impacts were not assessed.

5. FACILITY DECONTAMINATION AND WASTE DISPOSITION--Pg 2-4, Par. 2--
This paragraph discusses decontamination of the transfer lines and equipment. This decontamination process will generate both liquid and solid waste. Estimates of the nature of this decontamination waste and its environmental impact should be provided, as well as, a description of how the decontamination waste will be handled, including facilities needed to accomplish the decontamination and plans for disposal.

6. INCORRECT TRANSFER LINE FLOW RATES--Section 5, p 5-6, par. 1--
The transfer line leak scenario appears to incorrectly use a transfer line flow rate of 105 gpm, which is inconsistent with the sluicing pump output which would pump liquid from AY-102 at a rate of 350 gpm (pg. 2-2, par 3). The scenario should be re-evaluated to include the highest possible flow rate. Additionally, the probability that has been "determined" may not be correct. The EA should incorporate the probability calculations or a proper scientific reference.

7. WORKER PROTECTION FROM TANK C-103 TOXIC VAPORS--
There is nothing in the environmental assessment which addresses the problem of worker protection from organic vapors arising from Tank C-103. The assessment of a vapor release from C-103 during the sluicing operations is critical to the health and safety of the workers. Measures appropriate to mitigate the impact on workers from such releases should be identified.

8. RECOVERY FROM A LEAK FROM TANK C-106--Page 5-7, par 2.--
This paragraph implies that a surface barrier will be constructed over C-106 if a leak occurs. Further, it alludes to an action of recovering or treating any contaminated soils. These statements do not constitute an assessment of the impact of a release on the groundwater or unsaturated zone environment and remediation associated with these natural resources. As noted above, a proper and comprehensive assessment of these potential impacts, together with possible remediation, should be completed in the EA.

**Department of Energy**

Richland Operations Office
P.O. Box 550
Richland, Washington 99352

JAN 17 1995

94-TWP-104

Mr. Russell Jim, Manager
Confederated Tribes and
Bands of the Yakama Nation
P.O. Box 151
Toppenish, WA 98948

Dear Mr. Jim:

RESPONSES TO COMMENTS ON THE ENVIRONMENTAL ASSESSMENT (EA) FOR
TANK 241-C-106 PAST-PRACTICE SLUICING WASTE RETRIEVAL

The Department of Energy, Richland Operations Office (RL), appreciates your efforts in reviewing and commenting on the EA for Tank 241-C-106 Past-Practice Sluicing Waste Retrieval. Enclosed are RL's responses to your comments on this EA and one copy of the revised Preliminary Safety Evaluation for 241-C-106 Waste Retrieval, Project W-320, which includes the revised Chemical Compatibility of Tank Wastes in Tanks 241-C-106, 241-AV-101, and 241-AV-102 Report as an attachment. The EA is being revised to incorporate changes in response to your comments. We will send you a copy when it is finished.

If you or your staff wish to receive further information about this activity, please contact Mr. S. D. Bradley, of the Tank Waste Projects Division, on (509) 376-7333. If you desire further information about the National Environmental Policy Act (NEPA) process, please contact me on (509) 376-6667.

Sincerely,

Paul F. X. Dunigan, Jr.
Paul F. X. Dunigan, Jr.
NEPA Compliance Officer

PJR:SDB

Enclosures

cc w/o encls:
M. D. McKinney, PNL
H. R. Cook, YIN
R. Tulee, YIN

W. Rued, WAE

Department of Energy Richland Operations Office

Subject: Responses to the Yakama Indian Nation Comments on the Environmental Assessment (EA) for Tank 241-C-106 Past-Practice Sluicing Waste Retrieval, letter dated February 24, 1994.

1. According to WHC-EP-0182-64 (TF Surveillance and Waste Status), Tank AY-102 only has 131,000 gallons of space available. This leaves only 1,250 gallons difference between space available and the 129,750 gallons of waste needed to be sluiced. Additionally, the transfer lines will be flushed which will produce more liquid waste. Towards the end of the sluicing operation (after 75% of the waste has already been transferred) there will only be 3.5 minutes before the pumps must be shut off to prevent Tank AY-102 from being filled to capacity (based upon the 1,250 gallons of space mentioned above). The EA should specify the monitoring criteria which would prevent tank overflowing and the environmental impact from a spill or leak given the instrumentation capabilities.

Disposition of Comment 1: Section 2.2 has been expanded to include a discussion on the preliminary activities needed to Tank AY-102 to prepare it for sluicing operations. The 2nd paragraph (on page 2-5) explains that the supernatant currently in Tank AY-102 would be pumped out and sent to the Evaporator Bottoms System or another double shell tank (DST). Either Tank AY-101's supernatant or treated water would be pumped into Tank AY-102 to provide the initial sluicing agent. This would be done because both AY-101's supernatant and treated water have better compatibility characteristics with waste in Tank C-106 than the supernatant in Tank AY-102. The paragraph states, "...The removal of Tank AY-102's supernatant, even with the introduction of Tank AY-101's supernatant, would allow for sufficient space requirements for the receiver tank and would eliminate the potential for overflow as a result of the proposed sluicing operation".

2a. The EA does not indicate how the amount of liquid in C-106 will be minimized; what criteria will be used to decide when pumping from C-106 will occur, what additional controls (if any) will be installed to minimize the liquid. An explanation is needed in the EA on the sequence of events relative to pumping and sluicing.

Disposition of Comment 2a: The EA describes the process that would be involved in sluicing in Section 2.2 (which has been modified). The description emphasizes that the process would be a closed loop and would not introduce additional liquid to Tank C-106.

A paragraph has been added (page 2-3) which explains that at the start of sluicing, the slurry transfer pump in C-106 would be configured to run the slurry internally through the sluicers. This closed loop would be monitored to ensure that the proper consistency is reached before the slurry is transported to AY-102. This section (Section 2.2) has been modified to provide a more detailed description of the overall sluicing process, and indicates that this is a continuous, simultaneous process (where the volume being pumped out is roughly the same as the volume of supernatant added).

2b. The following questions should be resolved by engineering documents justifying sluicing: a) will the existing liquid in the tank be pumped prior to the introduction of the sluicing liquid? b) will the sluicing liquid be pumped from C-106 during the sluicing operation? c) will there be significant fluctuation in the liquid level? Appropriate operational limits should be specified in the procedures.

Disposition of Comment 2b: As has been mentioned, the 1st full paragraph of Page 2-3 states that the liquid currently in C-106 would be pumped out to improve sluicing efficiency prior to the actual sluicing. The revised Section 2.2 describes the process used in this project which mentions that the supernatant would be used to sluice the sludge and form a slurry. This slurry would be pumped through the transfer lines into Tank AY-102. The heavier particles would settle out under gravity while the relatively clear liquid would remain on top to be used as the supernatant (and thereby forming a continuous operation). The greatest liquid level would be at the start of operations. The slurry pump would remove the slurry at roughly the same rate as the supernatant is added, keeping the liquid level fairly constant (approximately 5,000 gallons). The overall waste volume would steadily decrease throughout the project.

3a1. Questions remain about the current ability to detect leaks. An engineering assessment of the SST waste leak detection capability should be completed and included in the tank leak engineering study, which should, in turn, be referenced in the EA.

Disposition of Comment 3a1: The EA was modified to include a discussion on the ability to detect leaks during sluicing. Both Section 2.2 (3rd paragraph on page 2-4) and Section 5-2 (first paragraph on page 5-11) mention that the presence of flow meters on the transfer lines and mass balance controls on the receiver tank would detect a leak when approximately 8,000 gallons were lost.

3a2. The EA should provide a credible assessment of a leak of 200,000 gallons.

Disposition of Comment 3a2: Due to the presence of the above controls, a leak of 200,000 gallons from sluicing is unrealistic and overly conservative (see response to Comment 3b3).

3b1. Concerns exist with the integrity of Tank C-106. Additional studies are needed to identify the source for the current soil contamination in and around C-Farm.

Disposition of Comment 3b1: A paragraph was added on page 2-1 explaining why C-106 has been characterized as sound. In 1992, the ventilation system failed and the tank was monitored for a period of roughly six months. During this time, with no additional cooling water added, the level of waste within C-106 remained constant.

3b2. Sluicing should not be allowed until information is available on if the tank is currently sound, if it has leaked in the past, if it is possible to sluice with a minimal amount of free liquid in the tank to mitigate a potential leak.

Disposition of Comment 3b2: The tank will be sluiced with a maximum of 5,000 gallons of supernatant added to the sludge at any time. The maximum amount of waste that could be released under these conditions would be the 5,000 gallons and any interstitial liquid in the waste.

3b3. To evaluate a worst case scenario, the EA should examine a leak of over 200,000 gallons. In any case, adequate tank integrity characterization should be performed and operation controls should be put into place to minimize the possibility of a large leak.

Disposition of Comment 3b3: As has been mentioned, leak detection devices would identify a leak when approximately 8,000 gallons of liquid is unaccounted for in the sluicing process. The EA further mentions that a conservative estimate of a leak is 40,000 gallons (and would be determined by the amount of free liquid in the tank, the detection devices, and the ability of the waste to plug the leak site). It is unrealistic to address a leak of 200,000 gallons from routine sluicing operations, when the total waste volume in C-106 would be less than this amount. The sluicing process, by working from the center outward, is designed to minimize the amount of waste that could leak to the environment. By the time the sluicers are applied to waste near the tank walls, the amount of waste would be greatly reduced.

4. More detail is warranted in the EA on leak detection of the transfer lines and pump pits. A more rigorous assessment is needed to determine the probability of a spill and the instrumentation required to assess the spill.

Disposition of Comment 4: The pump pits would return any leaked waste back into their respective tanks. The transfer lines would collect waste from a break in the primary pipe and carry it to a common point for leak detection. There is a discussion of these points on Page 5-2 (3rd and 4th paragraphs). Please see attached two sheets on design requirements.

The probability of a spill from the transfer lines has been determined to be 7.0×10^{-4} , the frequency of a Design Basis Earthquake at the Hanford Site.

5. A more thorough discussion of the decontamination process is needed, including the nature of the decontamination waste and its environmental impact.

Disposition of Comment 5: Decontamination of equipment and materials used in this project would produce roughly 7,000 gallons of additional liquid waste which would be sent to AY-102 and would still be well within the operating capabilities of that tank. The equipment would be excessed where practical or disposed of as waste. The volume of liquid waste generated from this action is mentioned on Page 5-16.

6. The transfer line leak scenario should use the pump flow rate of 350 gpm to be consistent with the description of the proposed action. The probability of this accident should be reexamined.

Disposition of Comment 6: Section 5.2 of the EA was revised to address comment contents.

7. Measures appropriate to mitigate the impact on workers from organic vapors which might arise from Tank C-103 should be identified.

Disposition of Comment 7: Section 5.1 page 5-3, 2nd paragraph of the EA was revised to state that proper respiratory equipment will be used as appropriate.

8. Statements in the EA on potential surface barriers should a leak occur and future recovery and treatment of contaminated soils, do not reflect an assessment of the impact of a release on the groundwater or unsaturated zone and remediation associated with these resources.

Disposition of comment 8: Wording was added to the EA to reflect that the accident scenario of a tank rupture from a DBE (which has the possibility of the most severe waste release to the soil) is not exclusive to the proposed action. This accident could occur during normal tank storage activities and, therefore, should not be a factor in determining the environmental significance of this project. Existing wording in the EA explain that a postulated leak would take a minimum of 60 years to reach the groundwater (and only the most mobile portion of the leak). The EA also explains that contaminated soil from such a spill would likely be remediated as part of the overall site closure of the tank farms under the TPA Milestone (M-45-06).

**TANK 241-C-106
PAST-PRACTICE SLUICING
WASTE RETRIEVAL**

HANFORD SITE, RICHLAND, WASHINGTON

U.S. DEPARTMENT OF ENERGY

FINDING OF NO SIGNIFICANT IMPACT

FEBRUARY 1995

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AGENCY: U.S. Department of Energy

ACTION: Finding of No Significant Impact

SUMMARY: The U.S. Department of Energy (DOE) has prepared an Environmental Assessment (EA), DOE/EA 0933, to assess environmental impacts associated with past-practice sluicing as a means of waste retrieval for Tank 241-C-106 (Tank C-106), and activities necessary to support this work at the Hanford Site, Richland, Washington. Tank C-106 is an underground single-shell tank (SST) located in the 241-C Tank Farm in the 200 East Area of the Hanford Site. Alternatives considered in the review process included: the No Action alternative; the preferred alternative to remove heat-producing sludge from Tank C-106 by sluicing using a high-volume, low-pressure stream of liquid to mobilize sludge waste for transfer through two transfer lines to a receiver tank, Tank 241-AY-102 (Tank AY-102), an underground double-shell tank (DST) also located in the 200 East Area; and a batch-transfer alternative that would use an accumulation tank connected to the transfer lines to hold in turn the supernate from Tank AY-102 that would be used to sluice the waste in Tank C-106, then the sluiced solids from Tank C-106 to be sent to Tank AY-102.

Based on the analysis in the EA, and considering preapproval comments from the Yakama Indian Nation, DOE has determined that the proposed action is not a major federal action significantly affecting the quality of the human environment within the meaning of the *National Environmental Policy Act of 1969* (NEPA), 42 U.S.C. 4321, et seq. Therefore, the preparation of an Environmental Impact Statement (EIS) is not required.

ADDRESSES AND FURTHER INFORMATION

Single copies of the EA and further information about the proposed action are available from:

Leif Erickson, Director
Tank Waste Disposal Division
U.S. Department of Energy
Richland Operations Office
P. O. Box 550
Richland, Washington 99352
(509) 376-6406

For further information regarding the DOE NEPA process, contact:

Carol M. Borgstrom, Director
Office of NEPA Oversight
U.S. Department of Energy
1000 Independence Avenue, S.W.
Washington, D.C. 20585
(202) 586-4600 or (800) 472-2756

PURPOSE AND NEED: DOE needs to take action to eliminate safety concerns with the storage of high-heat waste in Tank C-106, and demonstrate a tank retrieval technology.

BACKGROUND: In November 1990, Public Law 101-510, Section 3137, "Safety Measures for Waste Tanks at Hanford Nuclear Reservation" was enacted, which mandated that the DOE develop plans for response to safety issues associated with the waste storage tanks at the Hanford Site, and to report the progress of implementation of those plans to the U.S. Congress. In the resulting "Status Report on Resolution of Waste Tank Safety Issues at the Hanford Site," Tank C-106 is identified as a high-heat tank and one of the "Priority 1" safety issues at the Hanford Site.

Tank C-106, which was built during 1943 and 1944, measures 23 meters (75 feet) in diameter. It contains 655,000 liters (173,000 gallons) of sludge containing a sufficient amount of strontium to be considered high-heat waste. It is estimated that this sludge generates 32.24 plus or minus 5.86 kW (110,000 plus or minus 20,000 Btu per hour). This decay heat is being currently removed by the addition of approximately 22,700 liters (6,000 gallons) of water per month which provides evaporative cooling. It is believed that without active cooling, temperatures in the tank could exceed established limits and eventually affect the structural integrity of the tank resulting in a possible breach of containment. Also, the continued additions of cooling water would increase the amount of material available to be released to the soil column if a loss of containment occurs due to the age of the tank.

In addition, sluicing the waste from Tank C-106 would demonstrate a form of tank waste retrieval as called for in *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) Milestone M-45-03-T1 "Complete SST Waste Retrieval Demonstration." While the sluicing operations would need to retrieve approximately 75

percent of the high-heat sludge to lower the heat output below 11.72 kW (40,000 Btu per hour) (the level at which active cooling is no longer required), the proposed action would attempt to retrieve as much waste as possible beyond this 75 percent to demonstrate waste retrieval efficiency.

PROPOSED ACTION: The waste retrieval operation would involve introducing a high-volume, low-pressure stream of liquid to mobilize the sludge waste in Tank C-106 and prepare it for pumping. One or two remotely-aimed "slucers" would be installed in Tank C-106 at separate locations to ensure full sluicing coverage of the waste. The mobilized waste would be retrieved from Tank C-106 with a submersible pump that would transfer the waste to Tank AY-102 through one of the two newly installed, double-encased pipelines. The waste would be deposited in the receiver tank where the majority of the heavier solid waste particles would settle to the bottom while the liquid portion would remain on top as supernate to be recycled to Tank C-106 as the liquid sluicing agent. A sluice pump would be installed in Tank AY-102 to provide this sluicing agent. The two pipelines, one carrying the sluiced waste to Tank AY-102 and one carrying the supernatant back to Tank C-106, would be partially buried and covered by an earthen berm to reduce radiation dose to tank farm workers.

One of the slucers in Tank C-106 would operate in the existing sluice pit, while the other would operate in the existing pump pit, if needed. Valves would direct the supernate liquid to one of the slucers depending upon the area of the tank being sluiced. If it is determined that portions of the waste cannot be mobilized by the one sluicer, the valves would direct the supernatant into the second sluicer. Only one sluicer would operate at any one time.

A new submersible pump would be installed in Tank C-106 to transfer the slurry (i.e., the sluiced waste) to Tank AY-102. To allow for slurry elevation changes, the slurry transfer pump would be manually adjusted to maintain sufficient suction-head pressure. The sluicing operations would start from the center of the tank and work to the outside by remotely adjusting the angle of the slucers. This is designed to minimize the time that the tank liner is directly exposed to the sluice stream, and minimize the potential for a sluicing-induced tank leak.

The slurry would be pumped into the transfer line and deposited into Tank AY-102. A slurry distributor would evenly spread the Tank C-106 waste solids in Tank AY-102. This provides a more uniform heat source in Tank AY-102. The distributor also would provide a siphon break to the transfer line back to Tank C-106.

Prior to the sluicing operations, several actions would be required to prepare the tanks for the insertion of the pumps and equipment. Some of the existing equipment in the pump and sluice pits of Tank C-106 must be removed and stored at the Hanford Site for subsequent treatment and disposal. These pits would then require cleaning and the application of paint or fiber coating to the inside surface, which would provide a surface that can be more easily decontaminated. Before the waste from Tank C-106 can be transferred, the supernatant from Tank AY-102 would be pumped out to allow for sufficient space for the waste transfer. After the supernatant from Tank AY-102 is pumped out, supernatant from Tank AY-101 or other appropriate sluicing fluid (which may consist of treated water), would be pumped into Tank AY-102 to be used as the initial sluicing agent.

A new High-Efficiency Particulate Air (HEPA) filtration system would be added to Tank C-106 to minimize releases to the atmosphere. To control the temperature and humidity of the Tank C-106 vapor space during sluicing, the proposed action would install a recirculating air system. Additional methods of cooling the tank may be used, as necessary which may consist of either connecting an air chiller to the recirculation duct or by introducing cooled fluid prior to, or during, the sluicing operation. Additional instrumentation would be required in both tanks and in the transfer lines between the tanks. A double-wide trailer would be installed outside the 241-C Tank Farm, and would serve to house centralized monitoring and control instrumentation. Finally, support services, in the form of raw water, sanitary water, electrical power, telecommunications, and hoisting hardware, would be provided.

ALTERNATIVES CONSIDERED: The EA discussed a variety of sluicing alternatives as well as the No Action Alternative. Of the sluicing alternatives, all but one, the Batch Transfer Alternative, failed to meet the two essential requirements necessary for this project; the ability to remove enough of the waste so that the heat production in Tank C-106 is less

than 11.72 kW (40,000 Btu) per hour, and that the sluicing method start retrieval by October 1996. The other alternatives discussed in the EA either resulted in the generation of greater quantities of liquids requiring tank farm storage or rely upon technologies unproven in a waste tank environment.

Batch-Transfer Alternative. Of the alternatives described in the EA, the only option that could conceivably meet the two requirements was the Batch-Transfer Alternative. This alternative would utilize an accumulation tank which would hold both the supernatant from Tank AY-102 and the slurry from Tank C-106 at various times. The accumulation tank would first be filled with supernate from Tank AY-102, which would be used to sluice the waste in Tank C-106. The solids from Tank C-106 would then be transferred to this accumulation tank and the material batch transferred to the receiver tank. The accumulation tank then would be refilled with supernate from Tank AY-102 and the cycle repeated. While this alternative appears to meet the requirements, it would involve more design, procurement and construction costs, and would be less likely to meet the start date.

No-Action Alternative. This alternative would result in maintaining Tank C-106 in its present condition. No waste transfer operations will be performed, and the high-heat producing waste will continue to generate excessive thermal loads. Water additions to provide evaporative cooling will continue, which increase the amount of liquid available for release to the soil column in the event that the tank starts to leak. This alternative will not resolve the safety issue associated with Tank C-106 and will necessitate missing a Tri-Party Agreement milestone.

ENVIRONMENTAL IMPACTS: Routine conduct of the proposed activity would not result in any significant increase in tank farm emissions. Before beginning the proposed activity, appropriate procedures and administrative controls would be in place to maintain exposure to workers and other onsite personnel to within requirements established by DOE Orders and as low as reasonably achievable principles. The exposure received by onsite personnel is not expected to be greater than doses currently received from routine Hanford Site operations. Potential radiological doses to the public from routine operations would be extremely small and are not expected to result in any health effects. The risks to workers from chemical

exposures, noxious vapors, burns, and other common industrial hazards are expected to be low, and would be minimized by training and the use of appropriate personal protective equipment.

The Tank C-106 ventilation system would keep emissions within applicable regulatory requirements for gaseous and particulate discharges. The tank ventilation system would maintain a slight negative pressure inside Tank C-106 in the event of planned or unforeseen openings of the tank risers.

Most of the liquid necessary for the sluicing operations, after the initial supernatant transfers, would be obtained from and returned to Tank AY-102. Since the amount of slurry is approximately equal to the amount of supernate used to sluice the waste, the overall amount of liquid in Tank C-106 at any one time is not expected to increase substantially. Additional liquid might be required for sluicing line clean-out, but would not be a significant increase in total volume used, and would be within the receiving tank's storage capacity.

The proposed action would result in the generation of solid waste during the life of the project. Such waste would be surveyed and disposed of in the Hanford Site Solid Waste Landfill if uncontaminated, or another applicable, permitted location if found to be contaminated with hazardous or radioactive constituents. At the completion of activities, noncontaminated equipment would be excessed where applicable, while contaminated materials and components would be packaged and stored in a permitted facility as is the current practice at the Hanford Site.

The 200 East Area, and the project location specifically, is a developed, highly disturbed area, and is currently under a vegetation management program which eradicates vegetation. No sensitive or critical plant or animal habitat would be affected. There are no animal species of special concern which are known to use the area exclusively.

The proposed action would not release any particulate matter, thermal releases, or gaseous discharges in significant amounts. Noise levels would rise only slightly for the duration of the project with the majority of the impact during the early construction phase.

Leaks in the pump and sluice pits would be detected and controlled by special instrumentation during normal sluicing operations. Pit drains would return leaked wastes to one of the two tanks involved for compatible storage. Leaks in the primary piping system of the transfer lines would be controlled by the secondary containment system (the outer pipe). This secondary containment system would be designed to collect released waste at a common point for detection and removal.

Socioeconomic Impacts

Existing Hanford workers will perform the preparations and sluicing. Therefore no socioeconomic impacts are expected from this action.

Cumulative Impacts

The proposed action is not expected to contribute substantially to the overall cumulative impacts from operations on the Hanford Site. Standard Operating Procedures will provide sufficient personnel protection such that exposure to radiological and chemical materials will be kept below DOE and contractor guidelines. Routine sluicing operations are not expected to significantly increase the amount of radioactivity released from total Hanford operations. In 1993, the maximally exposed offsite individual was exposed to 3.7×10^{-3} millirem EDE from total air emissions, well below allowable limits set by state and federal regulations. The wastes generated from the activities would not add substantially to waste generation rates at the Hanford Site and would be stored or disposed in existing facilities.

Environmental Justice

Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations, requires that Federal agencies identify and address, as appropriate, disproportionately high and adverse human health or environmental effects of their programs and activities on minority and low-income populations. This proposed action would occur within the Hanford Site Boundary. Since no socioeconomic impacts or health effects are expected, it is not expected that there would be any

disproportionate adverse effects to low-income or minority populations in the surrounding community.

Impacts From Postulated Accidents

In addition to environmental impacts that were postulated from routine operations, the EA discussed a range of reasonably foreseeable accident scenarios that could lead to environmental impacts.

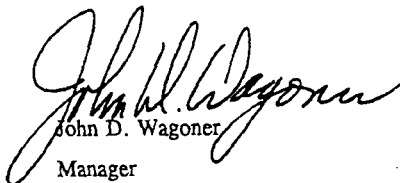
An unfiltered release through a breach in the recirculation duct of the ventilation system using the supernatant from Tank AY-102 as a source term was the accident scenario resulting in the highest dose to both onsite and offsite populations. The resulting 50-year committed dose from this potential accident was found to be 5.0×10^{-1} roentgen equivalent man (rem) Effective Dose Equivalent (EDE) for the onsite maximally exposed individual (MEI) and 5.2×10^{-4} rem EDE to the offsite MEI. The likely mechanism for this accident is a vehicular accident, which has a remote probability of occurring if proper administrative controls are in place; however, it is possible that a Design Basis Earthquake (DBE) could lead to similar results. It is not expected that there would be any latent cancer fatalities to either onsite or offsite populations from this accident.

Other accidents analyzed in the EA consisted of a waste transfer line break, a breach in tank confinement as a result of a DBE, a leak developing in the tank as a result of the sluicing operation, and a spray leak from a jumper or connector. It should be noted that a DBE has the potential to initiate three of the accident scenarios; a breach in the recirculation duct, a ⁵⁶rupture of the tank, and a break in the transfer lines. However, the impacts from the three accident scenarios, in terms of human health effects, would not be substantially greater than those described for the recirculation line breach except for a potentially greater amount of soil contamination. In addition, the EA examined the possibility of hazardous conditions existing in the receiver tank after sluicing. It was determined that no waste compatibility issues would result from the proposed action. It is not likely that the accidents which were analyzed would produce any cancer fatalities.

Other accidents that were not analyzed, such as tank dome failure due to exceeded weight limits, tank bottom penetration by dropped equipment, riser damage due to excavation and construction activities, have been analyzed by other tank farm facilities. Finally, the EA addressed the possibility of a sudden release of steam from a submerged waste layer which could overpressurize the tank and lead to a failure of the ventilation system. These accidents were found to have smaller risk, where risk equals the product of probability and consequence, than the accidents described in detail in the EA.

DETERMINATION: Based on the analysis in the EA, and after considering the preapproval review comments of the Yakama Indian Nation, I conclude that the proposed Past Practice Sluicing of Tank C-106 at the Hanford Site, Richland, Washington does not constitute a major federal action significantly affecting the quality of the human environment within the meaning of NEPA. Therefore, an EIS for the proposed action is not required.

Issued at Richland, Washington, this 17th day of February 1995.



John D. Wagoner
Manager

Richland Operations Office

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**Westinghouse
Hanford Company**

**Internal
Memo**

From: Waste Tank Process Control
 Phone: 373-2461 R2-11
 Date: December 6, 1994
 Subject: PROJECT W-320 REVISED HEADSPACE CHARACTERIZATION

71320-94-056

To: J. W. Bailey S6-12

cc: E. G. Allen G6-02 N. W. Kirch AOE R2-11
 B. Apolinario R2-70 T. H. May S6-12
 D. E. Bowers S6-01 D. A. Reynolds AOE R2-11
 J. C. Conner H4-61 SDE File/LB
 J. P. Harris S6-12

- Reference(s): (1) Internal Memo, S. D. Estey to J. W. Bailey, "Project W-320 Revised Headspace Characterization," dated December 16, 1993.
- (2) WHC-SD-WM-TI-565, "Radionuclide and Chemical Inventories for the Single-Shell Tanks," Rev. 1, dated 1993.
- (3) DSTRP-CY94-041, "Aerosol Characteristics in the Offgas from a Pilot-Scale Sluicing Operation," (Draft), dated 1994, Pacific Northwest Laboratory, Richland, Washington.

This memo revises the tank 241-C-106 (106-C) air stream characterization provided as design criteria for that tank's heating, ventilating and air conditioning (HVAC) unit for the Waste Recovery Sluicing System (WRSS). Subsequent to the development of the previous airstream characterization (Reference 1) the project baseline has changed, providing for the use of conditioned water for sluicing in place of dilute complexed supernatant. Current planning calls for sluicing the tank 106-C sludge with 1,900,000 liters (500 kgal) of water adjusted to 0.05 M [OH⁻] and 0.011 M [NO₂⁻]. This revised characterization accounts for the baseline change as well as incorporating numerous modeling refinements.

The primary non-atmospheric vapor constituent in tank 106-C headspace during sluicing operation is expected to be water. As a conservative assumption, the tank atmosphere is assumed to be saturated with water vapor. In the model described here, temperature effects only the concentrations of air and water in the tank headspace. Due to unknown WRSS operating characteristics and the potentially large energy input from the system pumps, an equilibrium water temperature is difficult to predict at present. The assumption of vapor-liquid equilibrium requires that the tank atmosphere be maintained at the same temperature as the circulating water. Tank atmospheric pressure is stated as 740 mm Hg (14.3 psia). Based on estimates of the WRSS operating characteristics which consider the waste heat input to the process from normal pumping operations and radioactive decay, the temperature of the sluicing water may well be capable, depending upon the actual efficiencies

J. B. Bailey
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December 6, 1994

of the WRSS, of reaching the operational temperature limit of 49°C (120°F). This temperature would require suspension of sluicing operations to allow the waste to cool by forced ventilation. However, the analyses indicate that 35°C (95°F) is a reasonable estimate of the equilibrium temperature for the circulating water and suspended wastes during Project W-320 sluicing operations should the WRSS perform as efficiently as desired. Additionally, 35°C (95°F) should be significantly warmer than the water temperature at the start of WRSS operations, allowing an ample operating margin for commencing the tank-to-tank sluicing activity. Therefore, 35°C (95°F) is chosen as the estimated equilibrium temperature for the circulating WRSS water or slurry solutions.

The presence of any significant quantities of ammonia and other volatile or semi-volatile vapor phase components in the headspace cannot be objectively justified by process knowledge or by available characterization data. Significant amounts of ammonia are not expected because none has been identified in the historical characterization data (Reference 2) and no source mechanism has been identified for its production in tank 106-C. This reasoning also applies to the presence of volatile organic compounds (VOC's). No characterization data on these compounds has been identified for tank 106-C sludge. The position that no VOC's exist in tank 106-C is supported by its thermal history in which its high temperatures indicate that any VOC's would have long since been exhausted from the tank. The analysis of gaseous emissions from studied single shell tanks has revealed an essentially non-existent tritium source term. Additionally, no characterization data on tritium concentrations has been identified for tank 106-C sludge. This characterization estimates that any concentrations of ammonia, VOC's and tritiated water in the atmosphere of tank 106-C during WRSS operations are below detectable limits, which is further defined here as being non-existent.

During the retrieval operation, it is anticipated that the sluicers, spraying large amounts of pressurized liquids with entrained radioactive sludge, will also contribute to the tank airstream mass loading by way of mists and aerosols. The generation of the mists and aerosols is the only mechanism by which significant quantities of radioactive materials can be introduced into the tank atmosphere. Since the mists and aerosols are mechanically generated, even non-volatiles can be suspended in the headspace. The liquids and solids so suspended are assumed to be composed of process water adjusted to the proper corrosion control chemistry, and tank 106-C sludge, itself a mixture of water and insoluble solids. The characterization data (Reference 2) provides no information on the existence of soluble component concentrations in the sludge. If the limiting water saturation conditions are not reached in the tank atmosphere, the aerosol concentrations may be affected by tank temperature and pressure. Therefore, varying temperature and conditions of water saturation in the tank atmosphere may alter the component mass distributions in the sluice generated aerosols. However, because of the complexities of modeling aerosol behavior in an unsaturated atmosphere, this characterization specifies that the aerosol contribution to the airstream mass loading will not change based on variations in atmospheric temperature, pressure, or degree of saturation.

The limit for slurry transfer from tank 106-C to tank 102-AY is 30 wt% solids, and a limit of 10 wt% solids is assumed for the maximum amount of solids in the sluice flow being returned to tank 106-C. The characterization data, as shown in Attachment 1, indicates that tank 106-C sludge contains no soluble solids (salts) and is approximately 41% by weight insoluble solids and 59% by weight water. This analysis assumes that the maximum activity of the sluice stream will be reached when a 10 wt% solids slurry is uniformly built-up throughout the WRSS. This corresponds to the situation where no settling of insoluble solids occurs during sluicing operations. With a water volume of 1,900,000 liters (500,000 gallons), a 10 wt% solids slurry would be initially reached after about 600,000 kg sludge in tank 106-C (about 56% of the total estimated sludge content in tank 106-C removal from tank 106-C would require that an equal amount of sludge settles in the receiving tank, 102-AY, to prevent exceeding the solids loading limit in the sluice stream. These calculations are shown in Attachment 2.

Due to the many concerns regarding the complexities of aerosol generation and characterization as applied to the WRSS operations, Project W-320 commissioned PNL testing in hopes of refining some of the estimates made in the previous airstream characterization (Reference 1). The findings of the PNL testing activities are described in Reference 3, which indicate that earlier estimates of aerosol loading were lacking in conservatism. Descriptive information can be found for both wet aerosols (aerosols with insoluble solids and liquids of water and soluble solids (salts) in solution) and dry aerosols (the wet aerosols after evaporation to dryness). Results of the PNL testing indicated that insoluble solids in the aerosols would preferentially settle out of the tank headspace when compared to liquid aerosols, such that the ratio of aerosol insoluble solids mass to liquid mass is only approximately one-half that of the source stream sprayed into tank 106-C.

The PNL testing referenced by this analysis was based on a feed slurry characterized by 4.4% soluble solids, 8.9% insoluble solids, and a balance of water. This provided a breakdown of the aerosols by total mass concentration, composed of soluble solids (dissolved salts), insoluble solids, and water. These test results were scaled to estimate the behavior of the aerosols which will be generated by the sluicing operations in tank 106-C. These calculations are shown in Attachment 2. This Attachment provides the mass fraction values and subsequent scaling calculation upon which the aerosol composition is based.

With assumed characterizations of tank 106-C sludge and conditioned water, Attachment 3 determines the aerosol composition in the tank 106-C headspace. The results show a total aerosol mass of 313 mg/m^3 . Of this total, 95% of the aerosol mass is water, 4.8% of the mass is the insoluble solids from tank 106-C sludge, and 0.2% of the mass is the soluble solids formed by the NaOH and NaNO_2 added to adjust water chemistry. These component distributions indicate an aerosol activity of $202 \text{ } \mu\text{Ci/m}^3$, which is contained entirely in the suspended insoluble solids. $^{89/90}\text{Sr}$ comprises about 85% of the total airstream activity.

J. B. Bailey
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71310-94-056

The size distribution ranges for the aerosols are reproduced from Reference 3 as follows:

Bulk Aerosol (Water, Soluble Solids, Insoluble Solids)

<u>Aerodynamic Particle Diameter Range</u>	<u>% of Total Wet Aerosol Mass</u>
> 10 μm	60 - 70
1 - 10 μm	20
< 1 μm	10 - 20

Dry Aerosol (Soluble Solids, Insoluble Solids)

<u>Aerodynamic Particle Diameter Range</u>	<u>% of Total Wet Aerosol Mass</u>
> 10 μm	30
1 - 10 μm	50
< 1 μm	20

In conclusion, the estimated characterization of the airstream from the tank 106-C atmosphere entering the HVAC system during sluicing operations is summarized as follows:

- water saturated air at 35°C (95°F), 740 mm Hg (14.3 psia)
- an aerosol mass loading of 313 mg/m³
- an aerosol composition of 4.8 wt% insoluble solids, 0.2 wt% NaOH and NaNO₂, as soluble solids from tank 106-C sludge, and 95.0 wt% water
- an activity of 202 $\mu\text{Ci}/\text{m}^3$
- an ¹²⁹I concentration of 7.1x10⁻⁶ $\mu\text{Ci}/\text{m}^3$
- no detectable concentrations of ammonia, VOC's, and ³H in the tank atmosphere.

S. D. Estey

S. D. Estey, Engineer
 Waste Tanks Process Engineering

mjg

Attachments

Characterization of Tank 241-C-108 Sludge

Characterization Data is from R. J. Van Vleet, 1993, "Radionuclide and Chemical Inventories for the Single-Shell Tanks" WHC-SD-WM-TI-568, Rev. 1, Westinghouse Hanford Company, Richland, Washington

Assumptions:

This analysis uses the characterization data reported in the source document for the tank sludge.

The characterization data is assumed to be reported on a bulk sample basis (i.e., per kg or per liter of the sludge sample).

This analysis considers the non-aqueous components of the sludge to be insoluble solids, and the non-aqueous components in the interstitial liquids to be soluble solids (however, the reference lists no chemical characterization data on interstitial liquids).

The reference document lists the density of tank 108-C sludge as both 1.75 and 1.43.

The spg. of 1.43 is chosen for the air stream characterization calculations.

This characterization assumes that drainable liquid listed in the reference document is not the same as the interstitial liquid in the sludge.

Because the drainable liquid activities are so much lower than the sludge activities,

any errors that would be introduced if this assumption is wrong are slight.

The reported activities of the sludge are adjusted to what should be expected from a 32 MW (110 kBtu/hr) decay heat load.

reported sludge spg. = 1.43E+00

Components	Reported mass of 108-C insoluble solids (mg/kg sludge)	Reported mass of 108-C interstitial liquids (mg/liter sludge)	Calculated mass of 108-C interstitial liquids (mg/kg sludge)	Calculated mass of 108-C soluble solids (mg/kg sludge)	Calculated mass of 108-C bulk sludge (mg/kg sludge)
Aluminum	1.15E+05	-	0.00E+00	0.00E+00	1.15E+05
Antimony	2.90E+03	-	0.00E+00	0.00E+00	2.90E+03
Arsenic	3.90E+02	-	0.00E+00	0.00E+00	3.90E+02
Barium	3.50E+02	-	0.00E+00	0.00E+00	3.50E+02
Boron	3.50E+02	-	0.00E+00	0.00E+00	3.50E+02
Calcium	1.90E+03	-	0.00E+00	0.00E+00	1.90E+03
Caesium	4.90E+02	-	0.00E+00	0.00E+00	4.90E+02
Chromium	1.75E+03	-	0.00E+00	0.00E+00	1.75E+03
Copper	3.00E+02	-	0.00E+00	0.00E+00	3.00E+02
Iron	8.24E+04	-	0.00E+00	0.00E+00	8.24E+04
Lead	2.50E+03	-	0.00E+00	0.00E+00	2.50E+03
Magnesium	4.20E+02	-	0.00E+00	0.00E+00	4.20E+02
Manganese	4.50E+03	-	0.00E+00	0.00E+00	4.50E+03
Neodymium	5.60E+02	-	0.00E+00	0.00E+00	5.60E+02
Phosphorus	7.30E+03	-	0.00E+00	0.00E+00	7.30E+03
Selenium	1.40E+03	-	0.00E+00	0.00E+00	1.40E+03
Silicon	2.60E+04	-	0.00E+00	0.00E+00	2.60E+04
Silver	2.10E+03	-	0.00E+00	0.00E+00	2.10E+03
Sodium	1.56E+05	-	0.00E+00	0.00E+00	1.56E+05
Strontium	1.10E+02	-	0.00E+00	0.00E+00	1.10E+02
Thallium	1.20E+03	-	0.00E+00	0.00E+00	1.20E+03
Titanium	3.30E+02	-	0.00E+00	0.00E+00	3.30E+02
Natural Uranium	4.09E+02	-	0.00E+00	0.00E+00	4.09E+02
Zirconium	6.00E+02	-	0.00E+00	0.00E+00	6.00E+02
Sum of non-aqueous components	4.09E+05	0.00E+00	0.00E+00	0.00E+00	4.09E+05
Water	-	-	0.00E+00	-	5.91E+05
Total	-	-	0.00E+00	-	1.00E+06

Calculated interstitial liquid spg. N/A
Calculated insoluble solids spg. = 2.05E+00

Radionuclides	Calculated* activity of 108-C insoluble solids (uCi/kg sludge)	Calculated* activity of 108-C interstitial liquids (uCi/liter sludge)	Calculated* activity of 108-C interstitial liquids (uCi/kg sludge)	Calculated* activity of 108-C soluble solids (uCi/kg sludge)	Calculated* activity of 108-C bulk sludge (uCi/kg sludge)
14 C	5.57E-01	0.00E+00	0.00E+00	0.00E+00	5.57E-01
60 Co	2.13E+03	0.00E+00	0.00E+00	0.00E+00	2.13E+03
89/90 Sr	4.75E+06	0.00E+00	0.00E+00	0.00E+00	4.75E+06
99 Tc	5.26E+02	0.00E+00	0.00E+00	0.00E+00	5.26E+02
129 I	1.94E-01	0.00E+00	0.00E+00	0.00E+00	1.94E-01
137 Cs	7.92E+05	0.00E+00	0.00E+00	0.00E+00	7.92E+05
239/240 Pu	5.46E+03	0.00E+00	0.00E+00	0.00E+00	5.46E+03
241 Am	2.52E+03	0.00E+00	0.00E+00	0.00E+00	2.52E+03
Total	5.56E+06	0.00E+00	0.00E+00	0.00E+00	5.56E+06

* calculated values are adjusted to equate to the 32 kW (110 kBtu/hr) tank decay heat load by multiplying reported values by 2.4

Determination of sluice stream composition at the limiting activity concentration.

The first issue is to determine the composition of the conditioned water to be used in the WRSS. What amount of NaOH and NaNO₂ must be mixed with what amount of process water so that the resulting solution meets DST corrosion control chemistry requirements (chosen as an OH- concentration of 0.05 M (0.85 g/l) and an NO₂- concentration of 0.011 M (0.51 g/l))?

The following information is known or assumed:

Water in the conditioned water solution has a spg. of 1.000.

1 g NaOH contains 0.425 g OH- and occupies a volume of 0.334 ml in solution. This gives dissolved NaOH an apparent spg. of 2994 g/l.

1 g NaNO₂ contains 0.667g NO₂- and occupies a volume of 0.356 ml in solution. This gives dissolved NaNO₂ an apparent spg. of 2809 g/l.

It is assumed that any volume changes upon mixing the caustic and salt with water is indicated by the value of the apparent spg. of that species in the solution.

The following relationships can be developed:

V_w is the volume fraction of water in the conditioned water solution.

V_{oh} is the volume fraction NaOH in the conditioned water solution.

V_{no2} is the volume fraction of NaNO₂ in the conditioned water solution.

The system of equations to be solved is:

$$V_w + V_{oh} + V_{no2} = 1.0 \text{ (liters)}$$

$$(V_{oh}(\text{liters}) * 2994 \text{ g/l} * 0.425 \text{ g/g}) / (V_w + V_{oh} + V_{no2}) = 0.85 \text{ g/l}$$

$$(V_{no2}(\text{liters}) * 2809 \text{ g/l} * 0.667 \text{ g/g}) / (V_w + V_{oh} + V_{no2}) = 0.51 \text{ g/l}$$

The equation solution uses the Mathcad 4.0 program (1), starting from initial guesses for V_w, V_{oh} and V_{no2}. Specific gravity of the resulting solution is stated as spgw:

$$V_w := 0.999$$

$$V_{oh} := 0.0005$$

$$V_{no2} := 0.0005$$

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given

$$V_w + V_{oh} + V_{no2} = 1$$

$$\frac{V_{oh} \cdot 2994 - 0.425}{V_w + V_{oh} + V_{no2}} = 0.85$$

$$\frac{V_{no2} \cdot 2809 - 0.667}{V_w + V_{oh} + V_{no2}} = 0.51$$

$$\text{find}(V_w, V_{oh}, V_{no2}) = \begin{pmatrix} 0.99906 \\ 0.000668 \\ 0.000272 \end{pmatrix}$$

water := 0.99906 · 1.000	water = 0.99906	kg of water per liter of conditioned water
NaOH := 0.000668 · 2.994	NaOH = 0.00200	kg of NaOH per liter of conditioned water
NaNO2 := 0.000272 · 2.809	NaNO2 = 0.00076	kg of NaNO2 per liter of conditioned water
spgw := water + NaOH + NaNO2	spgw = 1.00182	spg. of conditioned water (kg/l)
chem := NaOH + NaNO2	chem = 0.00276	kg of NaOH and NaNO2 per liter of conditioned water
masswater := $\frac{\text{water}}{\text{spgw}}$	masswater = 0.99724	kg of water per kg conditioned water
massNaOH := $\frac{\text{NaOH}}{\text{spgw}}$	massNaOH = 0.00200	kg of NaOH per kg conditioned water
massNaNO2 := $\frac{\text{NaNO2}}{\text{spgw}}$	massNaNO2 = 0.00076	kg of NaNO2 per kg conditioned water

The result is that the volume fraction of process water = 0.99906, the volume fraction of the added NaOH is 0.000668, and the volume fraction of the added NaNO2 is 0.000272. One liter of chemically conditioned water will contain 999.06 grams of water with 2.00 grams NaOH and 0.76 grams NaNO2 in solution. The spg. of the conditioned water is 1.00182.

The water volume chosen for the WRSS upon which the airstream characterization is based is 1,900,000 liters (500,000) gallons of water adjusted to a [OH-] of 0.05 M and an [NO₂-] concentration of 0.011 M. The model assumes that early in the sluicing operation the slurry solids concentration builds up uniformly to 10wt%, and until this point is reached the ratio of the concentration of insoluble solids to soluble solids is equal to the ratio of those solids in the bulk 106-C sludge adjusted for NaOH and NaNO₂ added to the water for corrosion control. At this point, a given amount of sludge from tank 106-C will have been sluiced out and converted into the uniform 10wt% solids loading of the slurry in the WRSS. Thereafter, the 10wt% solids limit must not be exceeded in the sluice header. Therefore, any further transfer of sludge out of tank 106-C must be accompanied by a continuous settling out of insoluble solids in tank 102-AY.

Knowing the volume and composition of water in the WRSS, a simple mass balance allows a determination of the amount of sludge which must be sluiced from tank 106-C to achieve a uniform 10wt% solids slurry throughout the system.

mass fraction (mf) = mass of all solids/(mass of all solids + mass of all water)

mf = mass of (sludge solids + NaOH + NaNO₂)

mass of (sludge solids + NaOH + NaNO₂ + interstitial water + process water)

mf(mass of (sludge solids + NaOH + NaNO₂ + interstitial water + process water)) = mass of (sludge solids + NaOH + NaNO₂)

mass of (sludge solids) - mf(mass of sludge (solids + interstitial water)) = mf(mass of (NaOH + NaNO₂ + process water)) - (mass of (NaOH + NaNO₂))

However, the mass of sludge solids + interstitial water is equal to the mass of sludge, and the ratio of the mass of sludge solids to the mass of sludge is known (0.409 from Attachment 1)

0.409(mass of sludge) - mf(mass of sludge) = mf(mass of (NaOH + NaNO₂ + process water)) - (mass of (NaOH + NaNO₂))

(0.409 - mf)(mass of sludge) = mf(mass of (NaOH + NaNO₂ + process water)) - (mass of (NaOH + NaNO₂))

mass of sludge = [mf(mass of (NaOH + NaNO₂ + process water)) - (mass of (NaOH + NaNO₂))]/(0.409 - mf)

solids := 0.1 mass fraction (mf) of solids in slurry

w := 1900000 volume of water in WRSS (l)

insf := 0.409 mass fraction of insoluble solids in 106-C sludge (from Attachment 1)

sof := 0.000 mass fraction of soluble solids in 106-C sludge (from Attachment 1)

sludgef := insf + sof mass fraction of total solids in 106-C sludge

inf := 1 - sludgef mass fraction of interstitial water in 106-C sludge

$$\text{mass} := \frac{\text{solids} \cdot (\text{spgw} \cdot \text{w}) - \text{w} \cdot \text{chem}}{\text{sludge} - \text{solids}}$$

mass of 106-C sludge which must be sluiced out of the tank to first achieve a 10wt% solids slurry (kg)

$$\text{mass} = 5.99013 \cdot 10^5$$

$$\text{insf} \cdot \text{mass} = 2.44996 \cdot 10^5$$

$$\text{solf} \cdot \text{mass} = 0.00000$$

corresponding insoluble and soluble masses in the above sludge mass

$$\frac{\text{insf} \cdot \text{mass} + \text{solf} \cdot \text{mass} + \text{w} \cdot \text{chem}}{\text{w} \cdot \text{spgw} + \text{mass}} = 0.10000$$

check of the mass fraction of solids in this slurry

$$\frac{\text{insf} \cdot \text{mass}}{\text{insf} \cdot \text{mass} + \text{solf} \cdot \text{mass} + \text{w} \cdot \text{chem}} = 0.97901$$

fraction of solids that are from 106-C insoluble solids

$$\frac{\text{solf} \cdot \text{mass}}{\text{insf} \cdot \text{mass} + \text{solf} \cdot \text{mass} + \text{w} \cdot \text{chem}} = 0.00000$$

fraction of solids that are from 106-C soluble solids

$$\frac{\text{w} \cdot \text{chem}}{\text{insf} \cdot \text{mass} + \text{solf} \cdot \text{mass} + \text{w} \cdot \text{chem}} = 0.02099$$

fraction of solids that are from added NaOH & NaNO2

rhoslurryC106 is the density of the sluice stream returned to tank 241-C-106 (kg/l). It is assumed that the clear solution density (soluble solids in water) is given by the relationship: Solution Density = 0.0085935(wt% salt) + 0.99345. The mass and volume of the suspended insoluble solids is then factored into the density equation:

(mass of insoluble solids + mass of solution)/(volume of insoluble solids + volume of solution)

$$\rho_{\text{slurryC106}} := \frac{\text{mass} + \text{w} \cdot \text{spgw}}{\left(\frac{\text{insf} \cdot \text{mass}}{2.05} \right) + \left[\frac{\text{w} \cdot \text{spgw} + \text{solf} \cdot \text{mass} + \text{intf} \cdot \text{mass}}{0.0085935 \cdot \left(100 \cdot \frac{\text{solf} \cdot \text{mass} + \text{w} \cdot \text{chem}}{\text{solf} \cdot \text{mass} + \text{intf} \cdot \text{mass} + \text{w} \cdot \text{spgw}} \right) + 0.99345} \right]}$$

$$\rho_{\text{slurryC106}} = 1.04824$$

$$\text{C106solwt\%} := \frac{(\text{solf} \cdot \text{mass} + \text{w} \cdot \text{chem}) \cdot 100}{\text{w} \cdot \text{spgw} + \text{mass}}$$

wt% soluble solids in the sluice stream returned to tank 241-C-106

$$\text{C106solwt\%} = 0.20986$$

$$\text{C106insolwt\%} := \frac{(\text{insf} \cdot \text{mass}) \cdot 100}{\text{w} \cdot \text{spgw} + \text{mass}}$$

wt% insoluble solids in the sluice stream returned to tank 241-C-106

$$\text{C106insolwt\%} = 9.79014$$

$$\text{C106H2Owt\%} := \frac{(\text{water} \cdot \text{w} + \text{intf} \cdot \text{mass}) \cdot 100}{\text{w} \cdot \text{spgw} + \text{mass}}$$

wt% water in sluice stream returned to tank 241-C-106

$$\text{C106H2Owt\%} = 90.00000$$

Reference 3 presents scaling equations to be used to estimate the aerosol densities present in the headspace of tank 241-C-106 during sluicing. The expected sluicing slurry composition is ratioed to the test slurry composition and the experimental results which were determined. From the process mass balance information, this 10 wt% solids slurry has a spg. of 1.04545 and is composed of 90 wt% water, 6.43 wt% insoluble solids, and 3.57 wt% soluble solids. The information below is taken from Reference 3 describing the test condition with both soluble and insoluble solids:

testmgsol := 15.1	mg/m3 of soluble aerosols in test air (dry basis)
testsolwt% := 4.4	wt% soluble solids in pilot scale test sluice stream
testmginsol := 14.1	mg/m3 of insoluble aerosols in test air (dry basis)
testinsolwt% := 8.9	wt% insoluble solids in test sluice stream
pslurrytest := 1.09	slurry density of test fluid (kg/l)

The above parameters are used in the following equations to determine the masses of the various aerosol components in the tank 241-C-106 airstream:

$$x_{sol} := \left(\text{testmgsol} \cdot \frac{C106solwt\%}{testsolwt\%} \right) \cdot \left(\frac{pslurryC106}{pslurrytest} \right) \quad \text{mg/m3 (dry aerosol basis) of soluble aerosol expected in tank 241-C-106}$$

$$x_{insol} := \left(\text{testmginsol} \cdot \frac{C106insolwt\%}{testinsolwt\%} \right) \cdot \left(\frac{pslurryC106}{pslurrytest} \right) \quad \text{mg/m3 (dry aerosol basis) of insoluble aerosol expected in tank 241-C-106}$$

$$x_{td} := x_{sol} + x_{insol} \quad \text{total mg/m3 (dry aerosol basis) expected in tank 241-C-106}$$

$$x_{tw} := x_{sol} + x_{insol} + x_{sol} \cdot \frac{C106H2Owt\%}{C106solwt\%} \quad \text{total mg/m3 (wet basis aerosol) expected in tank 241-C-106}$$

Solving the four equations yields:

$$x_{sol} = 0.69261$$

$$x_{insol} = 14.91601$$

$$x_{td} = 15.60861$$

$$x_{tw} = 312.63925$$

and, calculating the mass percentages of soluble solids, insoluble solids, and both combined:

$$100 \cdot \frac{x_{sol}}{x_{tw}} = 0.22154$$

$$100 \cdot \frac{x_{insol}}{x_{tw}} = 4.77100$$

$$100 \cdot \frac{x_{td}}{x_{tw}} = 4.99253$$

Summary

Code	Quantity	Value	Units	Equations (using Coded Identifiers for the applicable Quantities) & Notes
a	slurry solids fraction =	1.00E-01	(dimensionless)	..... given sludge flow solids limit
b	conditioned water volume =	1.90E+06	liters	..... value from conditioned water mass balance - page 2
c	conditioned water density =	1.00E+00	kg/liter	..... value from conditioned water mass balance - page 2
d	conditioned water salt concentration =	2.76E-03	kg/liter	..... value from conditioned water mass balance - page 2
"106-C Sludge Mass Fractions"				
e	fraction insoluble =	4.09E-01	(dimensionless)	..... value from Attachment 1
f	fraction soluble =	0.00E+00	(dimensionless)	..... value from Attachment 1
g	fraction all solids =	4.09E-01	(dimensionless)	..... value from Attachment 1
h	fraction interstitial water =	5.91E-01	(dimensionless)	..... value from Attachment 1
i	mass =	5.99E+05	kg	$(a * b * c - b * d) / (g - a)$ mass of sludge required to form the limiting slurry concentration
"10wt% Solids Slurry Mass Fractions"				
j	solids =	1.00E-01	(dimensionless)	a the limiting slurry solids mass fraction
k	106-C insoluble solids =	9.79E-02	(dimensionless)	$e * i / (a * b + i)$ the corresponding fraction of soluble slurry solids from C-106 sludge
l	106-C soluble solids =	0.00E+00	(dimensionless)	$f * i / (a * b + i)$ the corresponding fraction of insoluble slurry solids from C-106 sludge
m	NaOH & NaNO2 solids =	2.10E-03	(dimensionless)	$b * d / (a * b + i)$ the corresponding fraction of NaOH & NaNO2 from conditioned water in the slurry
n	slurry density =	1.05E+00	kg/liter	$(i + b * c) / ((e * i / 2.05) + ((b * c + f * i + h * i) / (0.0085935 * 100 * (f * i + b * d) + 0.99345) / (f * i + h * i + b * c)))$ specific gravity of the 10 wt% solids slurry with maximum radionuclide content
"10wt% Solids Slurry Mass Percentages"				
o	C-106 solwt% =	2.10E-01	wt%	$100 * (f * i + b * d) / (b * c + i)$ soluble solids in solution including NaOH & NaNO2
p	C-106 insolwt% =	9.79E+00	wt%	$100 * e * i / (b * c + i)$ insoluble solids suspended in the solution
q	C-106H2Owt% =	9.00E+01	wt%	$100 * (h * i + b * (c - d)) / (b * c + i)$ balance of water in the solution
"Data from Reference 3"				
r	testmg/sol =	1.51E+01	mg/m ³	..... obtained from test run in Reference 3
s	testsolwt% =	4.40E+00	wt%	..... obtained from test run in Reference 3
t	testmg/insol =	1.41E+01	mg/m ³	..... obtained from test run in Reference 3
u	testsolwt% =	8.90E+00	wt%	..... obtained from test run in Reference 3
v	test slurry density =	1.09E+00	kg/liter	..... obtained from test run in Reference 3
"Calculated Aerosol Quantities"				
..... obtained from scaling equations given in Reference 3				
w	xsol =	6.92E-01	mg/m ³	$(r * o / s) * (n / v)$ soluble solids concentration in aerosol including NaOH and NaNO2
x	xinsol =	1.49E+01	mg/m ³	$(t * p / u) * (n / v)$ insoluble solids concentration in aerosol
y	xtd =	1.56E+01	mg/m ³	w + x total solids concentration in aerosol
z	xtw =	3.13E+02	mg/m ³	w + x + w * q / o total aerosol concentration
	100 * xsol / xtw =	2.21E-01	wt%	100 * w / z mass % soluble solids in aerosol
	100 * xinsol / xtw =	4.77E+00	wt%	100 * x / z mass % insoluble solids in aerosol
	100 * xtd / xtw =	4.99E+00	wt%	100 * y / z mass % total solids in aerosol

From: Waste Tanks Process Engineering 75510-95-027
Phone: 373-2461 R2-11
Date: May 9, 1995
Subject: TANK 241-C-106 HEADSPACE ORGANIC CONCENTRATION DURING PROJECT
W-320 SLUICING OPERATIONS

To: J. P. Harris S2-48
cc: J. W. Bailey S6-12
W. B. Barton ~~WBB~~ R2-11
N. A. Homan H6-25
T. H. May S6-12
SDE File/LB

- References:
- (1) Internal Memo, S. D. Estey to J. W. Bailey, "PROJECT W-320 REVISED HEADSPACE CHARACTERIZATION," dated December 6, 1994.
 - (2) WHC-SD-WM-TI-578, "101-AY, 102-AY, & 106-C Data Compendium," Rev. 1, dated 1994.
 - (3) Internal Memo, S. D. Estey to J. W. Bailey, "PROJECT W-320 REVISED HEADSPACE CHARACTERIZATION," dated December 16, 1993.

Reference (1) provides the latest direction for the concentration and speciation of waste materials present in the atmosphere of tank 241-C-106 during sluicing operations. However, the waste characterization upon which the atmospheric model was based contained no provisions for the presence of organics, and therefore the model predicted that no organics would be present in the tank headspace. Project W-320 has since identified the need to specify the concentration of TOC present in the tank headspace during sluicing operations, as well as speciation of the constituents whose carbon atoms contribute to the value of TOC.

Reference (2) surveys the available characterization data for waste in tank 241-C-106 and provides a basis for the mass concentration of TOC contained within the tank waste. This memo will project an expected concentration of TOC in the headspace and will offer an estimated characterization of the TOC. Reference (3) provided a basis for the speciation of TOC in the headspace, and that basis will be expounded upon in this memo.

The mass of TOC in the sludge in tank 241-C-106 is taken from Reference (2) as 6.06 grams/kg, or a mass fraction of 0.00606. It is assumed that the concentration of solids (both soluble and insoluble) suspended in the headspace as aerosols has the same mass fraction of TOC. The suspended mass of aerosol solids is taken from Reference (1) as 15.6 mg/m³. Therefore, the mass of TOC suspended in aerosol form is assumed here as:

$$(15.6 \text{ mg/m}^3) * (0.00606) = 0.0945 \text{ mg/m}^3 \text{ TOC}$$

J. P. Harris
Page 2
May 9, 1995

From Reference (3), percentages of carbon in the TOC value are present as the carbon contained in salts of organic acids. These include the sodium salts of ethylenediaminetetraacetic acid (EDTA), N-hydroxyethyl-ethylenediamine triacetic acid (HEDTA), citric acid, and various degradation products of these materials in the following amounts:

sodium salt of EDTA	6.3 %
sodium salt of HEDTA	5.2 %
sodium citrate	29.5 %
sodium oxalate	29.5 %
sodium formate	29.5 %

The molecular weights (MW) of the organic species and grams of carbon per gram mole are:

<u>Component</u>	<u>MW</u>	<u>g carbon/amol</u>
sodium salt of EDTA [(NaOOCCH ₂) ₂ NCH ₂ CH ₂ N(CH ₂ COONa) ₂]	380	72
sodium salt of HEDTA [(NaOOCCH ₂) ₂ NCH ₂ CH ₂ N(C ₂ H ₄ OH)(CH ₂ COONa)]	343	72
sodium citrate [C ₃ H ₄ OH(COONa) ₃]	258	72
sodium oxalate [Na ₂ CCO ₂ Na]	102	24
sodium formate [HCOONa]	68	12

The masses of these organics in the headspace atmosphere are obtained by multiplying the fraction of the TOC contained in the individual organic species by the ratio of the (MW of the organic compound)/(grams carbon per mole of the organic compound):

$$\begin{aligned} \text{EDTA:} & (0.0945 \text{ mg/m}^3) * (0.063) * (380/72) = 0.031 \text{ mg/m}^3 \\ \text{HEDTA:} & (0.0945 \text{ mg/m}^3) * (0.052) * (343/72) = 0.023 \text{ mg/m}^3 \\ \text{citrate:} & (0.0945 \text{ mg/m}^3) * (0.195) * (258/72) = 0.066 \text{ mg/m}^3 \\ \text{oxalate:} & (0.0945 \text{ mg/m}^3) * (0.195) * (102/24) = 0.078 \text{ mg/m}^3 \\ \text{formate:} & (0.0945 \text{ mg/m}^3) * (0.195) * (68/12) = 0.104 \text{ mg/m}^3 \end{aligned}$$

$$\text{concentration of organics in headspace} = 0.302 \text{ mg/m}^3$$

If you have any questions please call me at 373-2461.

L. D. Estey

S. D. Estey, Engineer
Waste Tanks Process Engineering

mjg

Westinghouse
Hanford CompanyInternal
Memo

From: Waste Tanks Process Engineering 75510-95-040
 Phone: 373-2461 R2-11
 Date: June 23, 1995
 Subject: TANK 241-C-106 HEADSPACE ORGANIC CONCENTRATION DURING PROJECT
 W-320 SLUICING OPERATIONS

To: J. P. Harris S2-48

cc: J. W. Bailey S6-12
 W. B. Barton R2-11
 N. A. Homan H6-25
 T. H. May S6-12
 SDE File/LB

Reference: Internal Memo, S. D. Estey to J. P. Harris, "Tank 241-C-106 Headspace Organic Concentration during Project W-320 Sluicing Operations," dated May 9, 1995.

This Memo supersedes the direction of the Reference by providing additional conservatism in the logic and correcting various calculational errors.

The mass of TOC in the sludge in tank 241-C-106 is stated in the Reference as 6.06 grams/kg, or a mass fraction of 0.00606. This is further qualified by using as a basis the mass of sludge solids instead of the total sludge mass. This increases the mass fraction by a factor of 100/65 yielding a mass fraction value of 0.009323. The aerosol mass loading of TOC is then determined as 0.009323 times the mass of the suspended aerosol solids (15.6 mg/m³) or 0.1454 mg/m³. The distribution of organics remains at 6.3% sodium salt of EDTA, 5.2% sodium salt of HEDTA, 29.5% sodium citrate, 29.5% sodium oxalate, and 29.5% sodium formate.

The following corrections are made to the remaining calculations:

<u>Component</u>	<u>MW</u>	<u>g carbon/gmol</u>
sodium salt of EDTA [(NaOOCCH ₂) ₂ NCH ₂ CH ₂ N(CH ₂ COONa) ₂]	380	120
sodium salt of HEDTA [(NaOOCCH ₂) ₂ NCH ₂ CH ₂ N(C ₂ H ₄ OH)(CH ₂ COONa)]	343	120
sodium citrate [C ₃ H ₄ OH(COONa) ₃]	258	72
sodium oxalate [NaO ₂ CCO ₂ Na]	134	24
sodium formate [HCOONa]	68	12

J. P. Harris
Page 2
June 23, 1995

The masses of these organics in the headspace atmosphere are obtained by multiplying the fraction of the TOC contained in the individual organic species by the ratio of the (MW of the organic compound)/(grams carbon per mole of the organic compound):

EDTA: $(0.1454 \text{ mg/m}^3) * (0.063) * (380/120) = 0.0290 \text{ mg/m}^3$
 HEDTA: $(0.1454 \text{ mg/m}^3) * (0.052) * (343/120) = 0.0216 \text{ mg/m}^3$
 citrate: $(0.1454 \text{ mg/m}^3) * (0.295) * (258/72) = 0.1537 \text{ mg/m}^3$
 oxalate: $(0.1454 \text{ mg/m}^3) * (0.295) * (134/24) = 0.2395 \text{ mg/m}^3$
 formate: $(0.1454 \text{ mg/m}^3) * (0.295) * (68/12) = \underline{0.2431 \text{ mg/m}^3}$

concentration of organics in headspace = 0.6869 mg/m^3

In light of the uncertainties in this analysis, it is recommended that an organic concentration of 0.7 mg/m^3 be used.

S. D. Estey
 S. D. Estey, Engineer
 Waste Tanks Process Engineering

mjg

**Westinghouse
Hanford Company**
**Internal
Memo**

From: Waste Tanks Process Engineering 75510-95-031
 Phone: 373-2461 R2-11
 Date: May 25, 1995
 Subject: WASTE COMPATIBILITY EVALUATION FOR INHIBITED PROPYLENE GLYCOL

To: D. J. Minter S2-24

cc: E. G. Allen G6-02
 W. B. Barton *WJB* R2-11
 W. W. Jenkins S2-24
 J. R. Kriskovich S2-24
 R. A. Pina S2-47
 D. A. Reynolds R2-11
 SDE File/LB

- Reference(s): (1) Internal Memo, S. D. Estey to E. G. Allen, "WASTE COMPATIBILITY EVALUATION FOR INHIBITED PROPYLENE GLYCOL," dated March 23, 1994.
- (2) R. Reid; J. Prausnitz, T. Sherwood, THE PROPERTIES OF LIQUIDS AND GASES, 3rd ed., McGraw-Hill, New York, 1977.

Interpretation of Reference (1) lead to additional questions about the conditions under which propylene glycol could vaporize to form flammable mixtures in air. In the context of Project W-320, Tank 241-C-106 Sluicing, Reference (1) avoided these questions by stating that the necessary conditions for such an event could not occur. However, if this is not the case, postulated accident scenarios of an extreme nature could be thought to produce conditions whereby, provided a sufficient amount of fuel (propylene glycol) is present, a flammable mixture could form in the tank atmosphere. This memo analyzes these conditions, and makes the case that such conditions are incredible.

In every case, the minimal requirements would be that the liquid and vapor phases of the propylene glycol were at or above its flashpoint and that propylene glycol be present in sufficient quantities to form flammable mixtures in air. Reference (1) analyzed a formulated propylene glycol mixture containing about 5% detergent by mass with a stated flashpoint of 214°F. This memo considers only pure propylene glycol, which is conservative from a flammability standpoint (i.e., has a lower flashpoint). The flashpoint, 210 °F for pure propylene glycol, can be interpreted as the temperature at which the vapor pressure of the combustible liquid is high enough to form a flammable concentration in air. The conditions required are that a sufficient mass of fuel is present to produce the requisite amount of vapor, and that the vapor be allowed to concentrate in the volume of the tank atmosphere. Such

D. J. Minter
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 May 25, 1995

75510-95-031

conditions could occur as a result of an extended loss of forced ventilation.

The most simple condition to analyze is the presence of a volume of pure propylene glycol in contact with the atmosphere of the tank. If a sufficient mass of liquid propylene glycol pools on top of the sludge, the vapor pressure of propylene glycol will eventually reach its equilibrium value in a stagnant tank headspace. If the tank were dry the sludge would be more likely to reach or exceed 210°F. There must still be a heat transfer mechanism which could keep the tank atmosphere at or above 210°F, and if water is absent from the tank, sludge temperatures would have to increase drastically above 210°F in order to maintain the atmosphere at 210°F. It is highly unlikely that such a pool, or some other separated phase, of pure propylene glycol could form in the tank as the glycol would most likely enter the tank as a 50/50 water/glycol antifreeze mixture. In this case, the partial pressure of the glycol in the tank atmosphere would be reduced compared to the vapor pressure of the pure component.

In more realistic cases, the volume of water in the tank should be large compared to the volume of propylene glycol which could leak into the tank. If significant amounts of water are in the tank (eg. 30,000 gallons), the propylene glycol would be diluted to a very low concentration in the water, and the equilibrium concentration of its vapor above the glycol-water solution would have to be determined through analysis of vapor-liquid equilibrium data for a water-propylene glycol mixture. The simplest example would be a Henry's Law ($y = kx$) type of relationship, where y is the vapor phase mole fraction and x is the liquid phase mole fraction. In such cases, the effect of the dilution water will be to reduce the partial pressure of propylene glycol in the atmosphere when compared to the partial pressure of the pure component in contact with the atmosphere.

A calculation of the amount of propylene glycol which must evaporate to form an LEL condition in the headspace of tank 241-C-106 follows:

Given:

Propylene Glycol

MW = 76.11
 Specific Gravity = 1.0361
 Flash Point = 210°F
 Vapor Pressure @ 20°C = 0.07 mmHg
 LEL = 2.6%

A quick check of the properties of concern to vapor phase flammability is through verification that the vapor pressure of the material at its flash point is equivalent to the LEL. A method for estimating the vapor pressure of a pure substance as a function of temperature is provided by Antoine's

D. J. Minter
Page 3 of 4
May 25, 1995

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Equation. Reference (2) gives the following form of Antoine's equation for propylene glycol:

$$\text{vapor pressure (mmHg)} = \exp[20.534 - (6091.95/(T - 22.46))]$$

$$\text{where T is in K: } (T(K) = 273.15 + (5/9)*(T(^{\circ}\text{F}) - 32))$$

This equation yields a vapor pressure of 0.14 mmHg at 20°C (68°F) compared to the commonly stated value of 0.07 mmHg. At 210°F, the vapor pressure is calculated as 22.4 mmHg or 2.9%, which is close to the LEL of 2.6%. In this case, Antoine's equation produces a reasonable correlation between the vapor pressure at the stated flash point (210°F), and the LEL.

Determine volume of tank headspace:

$$\begin{aligned} \text{dome volume} &= 33,000 \text{ ft}^3 \\ \text{cylindrical volume} &= (500,000 \text{ gal} - 197,000 \text{ gal}) / (7.48 \text{ gal/ft}^3) \\ \text{total volume} &= 33,000 + 40,500 = 73,500 \text{ ft}^3 \end{aligned}$$

Determine lb mols (n_{air}) of gas in tank headspace at 210°F:

$$n = (P*V)/(R*T)$$

$$P = 1 \text{ atm}$$

$$V = 73,500 \text{ ft}^3$$

$$R = 0.7302 \text{ (ft}^3*\text{atm)/(lb mol}^{\circ}\text{R)}$$

$$T = (210^{\circ}\text{F} + 460^{\circ}\text{F})(^{\circ}\text{R}/^{\circ}\text{F}) = 670^{\circ}\text{R}$$

$$n_{\text{air}} = (1 \text{ atm} * 73,500 \text{ ft}^3) / (0.7302 \text{ (ft}^3*\text{atm)/(lb mol}^{\circ}\text{R)}) * 670^{\circ}\text{R}$$

$$n_{\text{air}} = 150 \text{ lb mols}$$

Determine lb mols of propylene glycol (n_{glycol}) required to reach the LEL in tank headspace:

$$n_{\text{glycol}} = n_{\text{air}} * \text{LEL}/100\%$$

$$n_{\text{glycol}} = 150 \text{ lb mols} * 2.6\%/100\% = 3.9 \text{ lb mols}$$

Converting to gallons of propylene glycol evaporated:

$$\begin{aligned} \text{volume} &= 3.9 \text{ lb mols} * (76.11 \text{ lb/lb mol}) / (8.34 * 1.0361 \text{ lb/gal}) \\ &= 34 \text{ gallons propylene glycol} \end{aligned}$$

Therefore, under the conditions mentioned previously, if 34 gallons of propylene glycol were to evaporate into a 210°F headspace, a flammable mixture

D. J. Minter
Page 4 of 4
May 25, 1995

75510-95-031

could be formed. This is the limiting condition which could only occur if the volume of liquid propylene glycol were present as a separable phase in the tank. If any propylene glycol leaking into the tank mixes with the water already in the tank, the partial pressure of the propylene glycol will be less than the vapor pressure of the pure substance. In this case, as a minimum requirement, temperatures higher than the flashpoint would be needed to form a flammable vapor concentration. Even then, the partial pressure of water may lower concentrations of fuel and oxidizer in the headspace to a level which would not support combustion. Therefore, the limiting condition, and thus the probability of formation of a flammable atmospheric mixture, is considered incredible because:

- 1) The propylene glycol would be added to the tank as a 50/50 mix with water.
- 2) Propylene glycol entering the tank would most likely be further diluted by a large volume of water already present in the tank.
- 3) The partial pressure of any water in the tank will dilute concentrations of both fuel (propylene glycol) and oxidizer (oxygen) in the headspace, possibly to the point where combustion could not occur.
- 4) The temperatures required to produce the necessary vapor pressure of propylene glycol could only result from an extended loss of forced ventilation (i.e., on the order of about one year at a minimum).
- 5) The history of tank farms always indicates that for steady gas/vapor release scenarios, the combination of natural or other inadvertent means of tank ventilation prevents the formation of flammable concentrations in the tank headspace.

S. D. Estey
S. D. Estey, Engineer
Waste Tanks Process Engineering

mjj

Concurrence:

D. A. Reynolds
D. A. Reynolds

5/25/95
Date

(signature indicates agreement with this memo and the supporting memo Reference (1))

**ICF KAISER
ENGINEERS**

A-94-001

ICF KAISER ENGINEERS, INC.
6400 UPTOWN BLVD., SUITE 397W
ALBUQUERQUE, NEW MEXICO 87110
505/881-1593 FAX 505/881-0614

January 10, 1994

Kaiser Engineers Hanford Company
1200 Jadwin Avenue
Richland, WA

Attention: Mr. D. J. Shrimpton

Reference: Project W-320, Tank 241-C-106 Sluicing

An analysis of the energy balance surrounding the referenced project has been completed. The report of results is enclosed. The purpose of the analysis and report is to illustrate the effect of various operating scenarios upon the temperature which may be attained in Tank AY-102.

As shown in the report, temperatures under certain scenarios may reach above 150 degrees Fahrenheit. The scenarios themselves include some cases where the assumptions are inconsistent with operating reality. For instance, operations are assumed to be continuous for up to one year with high stream factor and high solids loading of the transfer slurry. Under these conditions the transfer operation will either only take a very short time or the entire solids content of C-106 will be suspended and recycled without settling in AY-102. Thus these scenarios should be considered bounding rather than necessarily expected.

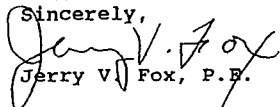
This analysis assumed as given the design performance of the C-106 vent recycle energy removal system. It is noted that the design point of this system for exhaust vapor is based on 95 degree temperature with 100 percent relative humidity. Should the temperatures reach well above 95 degrees, several impacts on the vent system should be considered. Included are:

- overloading of the exhaust cooler with condensate flooding the heat exchanger.
- overloading the compressor of the refrigeration unit.
- increasing the temperature requirements of the vent gas superheater.
- possible need for thermal protection insulation on some piping systems.

The report has been written in WordPerfect* 5.1 with tables generated by Microsoft Excel. Included in the transmittal are two bound copies, one unbound copy, and a disk file.

Reports from other subtasks will follow this week.

Sincerely,

A handwritten signature in cursive script that reads "Jerry V. Fox". The signature is written in dark ink and is positioned above the typed name.

Jerry V. Fox, P.E.

xc: R. Smith, ICF-KE-AL
W. Cureton, ICF-KE-LA
T. Thomas, ICF-KE-AL

*Wordperfect is a trademark of the Wordperfect Corporation. *KN*

United States Government

Department of Energy

memorandum

DATE: DEC 09 1993
 REPLY TO: EM-36
 ATTN OF:

SUBJECT: Delegation of Approval Authority to Streamline Tank Waste Remediation System (TWRS) Documentation

TO: Manager, DOE Richland Operations Office

Key elements for success of the tank safety program include developing high-quality documentation of Safety and Environmental Assessments (SAs/EAs) and streamlining the process used for approving these documents. Consistent with the division of roles and responsibilities addressed in Tom Grumbly's memorandum to you, dated August 23, 1993, the DOE Richland Operations Office (RL) has the primary responsibility to ensure that Westinghouse Hanford Company (WHC) documents are adequately reviewed and checked for quality. To accomplish this objective, RL must be technically and managerially capable of ensuring the development of high-quality SAs and EAs.

Secretarial Safety Initiatives issued on September 13, 1993, require DOE Headquarters (HQ) to take four actions in November 1993:

- Accept Interim Safety Basis;
- Delegate authority to RL for approval of Safety Analysis Reports;
- Delegate approval authority for National Environmental Policy Act (NEPA) documentation and Safety Assessments for the 106-C Sluicing Project on a pilot basis; and
- Delegate Program Secretarial Officer (PSO) approval authority, to the RL Manager, for procurement actions and Key Decisions 3 and 4, also on a pilot basis.

I plan to accept the Interim Safety Basis (ISB) and its implementing procedures based on your review and approval. As discussed in Jill Lytle's May 6, 1993, guidance memorandum to you concerning safety analysis for the Hanford high-level waste tank farms, the Headquarter focus will be to establish a comprehensive safety envelope considering all hazards from nuclear and chemical aspects that are important to worker protection and facility operations. Even though the ISB is based in part on existing Safety Analysis Reports (SARs), we recognize the need to support on-going operations and to proceed with certain activities related to the resolution of safety issues. Acceptance of the ISB is contingent on your aggressive development of a comprehensive safety basis by July 1994, as laid out in the Secretary's Safety Initiatives.

Regarding the delegation of approval authority for SAs and SARs, it appears there is an inconsistency in the Safety Initiatives. It is prudent for us to take a phased approach in delegating this critical authority. Therefore, we are delegating to the RL Manager the authority to approve safety documentation for the 106-C Sluicing Project on a pilot basis. Please submit a plan to us by January 10, 1994, describing how RL and the WHC would assume the authority and accountability for approving SARs for

all TWRS activities. Please ensure that this plan reflects the empowerment principles as discussed by the Secretary in her May 10, 1993, Town Meeting on Managing Today for Tomorrow's Success. We would propose that we plan to delegate approval authority for all TWRS SARs to the RL Manager, by April 1994, to allow RL and WMC the opportunity to demonstrate your planning/approval process with the Tank 106-C Sluicing Project safety and environmental documentation.


With respect to the NEPA documentation for the Tank 106-C Sluicing Project, by her signature on this memorandum you have been delegated the authority to approve the Tank 106-C EA and issue the finding of no significant impact, if appropriate, by the Assistant Secretary for Environment, Safety and Health. HQ staffs from the Offices of Environmental Restoration and Waste Management and Environment, Safety and Health will be developing performance measures to gauge the success of this delegation of authority.

We are now also delegating the PSD approval authority to the RL Manager for procurement actions and Key Decisions 3 and 4 on a pilot basis for the Tank 106-C Sluicing Project. RL will be responsible for fully documenting the Hanford decision-making processes and will continue to report progress to HQ. Current and updated planning and management control documents will be provided to HQ for information.

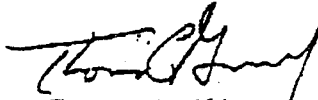
We, along with the Secretary, are committed to empowering the field; i.e., giving greater responsibility and accountability to the Operations Offices and Management and Operating contractors for program and project execution. We are interested in delegating appropriate responsibility to RL and WMC for all Hanford waste management programs and project management processes.

Please provide us your concepts and plans, in compliance with DOE Order 4700.1, for accepting these responsibilities and demonstrating accountability, with measurable performance measures. Identify the level of program/project management authority you deem appropriate, how you will implement the new responsibility, what impediments exist to successful program/project implementation, and what responsibilities need to be delegated from HQ. Please provide us your plan by January 10, 1994.

In all of these actions, it is critical that information flow upwards, unimpeded, from the subcontractors to WMC, to RL, and to HQ. Please call us or Jill Lytle if you have any questions. Staff contact for this program is John Tseng, 301-803-7170.



Tara O'Toole, M.D., M.P.H.
Assistant Secretary
Environment, Safety and Health



Thomas P. Grumbly
Assistant Secretary for Environmental
Restoration and Waste Management

Westinghouse
Hanford CompanyInternal
Memo

From: Consequence Analysis
 Phone: 376-2921 H4-64
 Date: October 19, 1995
 Subject: ESTIMATED DOSE TO ONSITE INDIVIDUAL FROM TANK C-106 TRANSFER POOL SPILL

BM400-BEH-95015

To: J. C. Conner

cc: L. E. Johnson
 D. S. Leach
 J. C. Van Keuren
 BEH LB

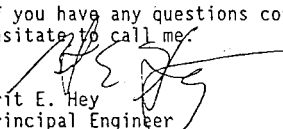
As requested, doses were calculated for the subject scenario using assumptions consistent with Section 3.4.2.3 of WHC-SD-WM-SAR-065, Rev. 0, "Interim Chapter 3.0 Hazard and Accident Analysis." Specifically these assumptions are:

1. The radioactive liquid spills onto flat ground and soaks down to a depth of 31 cm.
2. All radioactivity is captured in the top 5 cm of the soil layer.
3. Soil density is 1.6 g/cc and porosity is 30 %. Source shielding effectiveness is treated as low density concrete mixed with water.
4. The onsite individual is represented by a dose point 100 m from the nearest edge of the pool and 1.5 m above the ground.
5. The exposure duration is 8 hrs.

Results for two spill sizes of 320,000 and 5,200 L are 9.8 R and 170 mR respectively for an 8 hour exposure. Doses are approximately linear with pool spill volume. Therefore, alternate doses can be estimated by linear interpolation. Doses are also proportional to exposure time and approximately proportional to Cs-137 concentration. The bremsstrahlung dose due to Sr-90/Y-90 contributes less than 5% of the total dose.

Attached are the code output produced during the analysis. Also attached is the C-106 radionuclide inventory assumed in the analysis.


If you have any questions concerning this information, please do not hesitate to call me.


 Brit E. Hey
 Principal Engineer

gjr

Attachment

Concurrence:


 D. S. Leach, Manager
 Consequence Analysis

10/20/95
 Date

ATTACHMENT

CODE OUTPUT FOR ANALYSIS TO ESTIMATE DOSE TO ONSITE INDIVIDUAL FROM TANK C-106
TRANSFER POOL SPILL

MicroShield 4.00 - Serial #4.00-00128
Westinghouse Hanford Company

Page : 1
 DOS File: V1.MS4
 Run Date: October 19, 1995
 Run Time: 3:21 p.m. Thursday
 Duration: 0:02:55

File Ref: _____
 Date: ____/____/____
 By: _____
 Checked: _____

Case Title: Pool Spill of 320,000 L - Co, Cs and Eu Direct Contribution

GEOMETRY 8 - Cylinder Volume - End Shields

	centimeters	feet	and inches
Dose point coordinate X:	13340.0	437.0	8.0
Dose point coordinate Y:	150.0	4.0	11.1
Dose point coordinate Z:	0.0	0.0	.0
Cylinder height:	5.0	0.0	2.0
Cylinder radius:	3340.0	109.0	7.0
Air Gap:	145.0	4.0	9.1
Side Clad:	10000.0	328.0	1.0

Source Volume: 1.75232e+8 cm³ 6188.25 cu ft. 1.06933e+7 cu in.

MATERIAL DENSITIES (g/cm³)

Material	Source Shield	Air Gap	Side Clad Shield
Air		0.00122	
Concrete	1.6		1.6
Water	0.3		

BUILDUP

Method: Buildup Factor Tables
The material reference is Source

INTEGRATION PARAMETERS

	Quadrature Order
Radial	22
Circumferential	22
Axial (along Z)	22

SOURCE NUCLIDES

Nuclide	curies	μCi/cm ³	Nuclide	curies	μCi/cm ³
Ba-137m	2.1987e+005	1.2547e+003	Co-60	2.5937e+002	1.4801e+000
Cs-137	2.3242e+005	1.3263e+003	Eu-154	9.4574e+003	5.3971e+001

Page : 2
 DOS File: V1.MS4
 Run Date: October 19, 1995
 Run Time: 3:21 p.m. Thursday
 Title : Pool Spill of 320,000 L - Co, Cs and Eu Direct Contribution

===== RESULTS =====					
Energy (MeV)	Activity (photons/sec)	Energy Fluence Rate (MeV/sq cm/sec)		Exposure Rate In Air (mR/hr)	
		No Buildup	With Buildup	No Buildup	With Buildup
0.6625	7.417e+015	1.046e+004	5.263e+004	2.027e+001	1.020e+002
0.8723	4.910e+013	1.192e+002	4.879e+002	2.242e-001	9.180e-001
1.0024	9.948e+013	3.174e+002	1.181e+003	5.848e-001	2.176e+000
1.2651	1.391e+014	7.008e+002	2.249e+003	1.231e+000	3.951e+000
1.3325	9.597e+012	5.351e+001	1.665e+002	9.283e-002	2.889e-001
1.5767	1.233e+013	9.526e+001	2.706e+002	1.581e-001	4.491e-001
TOTAL:	7.726e+015	1.174e+004	5.698e+004	2.256e+001	1.098e+002

MicroShield*4.00 - Serial #4.00-00128
 Westinghouse Hanford Company

Page : 1
 DOS File: V2.MS4
 Run Date: October 19, 1995
 Run Time: 3:28 p.m. Thursday
 Duration: 0:04:23

File Ref: _____
 Date: ___/___/___
 By: _____
 Checked: _____

Case Title: Pool Spill of 5,200 L - Co, Cs and Eu Direct Contribution

GEOMETRY 8 - Cylinder Volume - End Shields

	centimeters	feet and inches	
Dose point coordinate X:	10430.0	342.0	2.3
Dose point coordinate Y:	150.0	4.0	11.1
Dose point coordinate Z:	0.0	0.0	.0
Cylinder height:	5.0	0.0	2.0
Cylinder radius:	430.0	14.0	1.3
Air Gap:	145.0	4.0	9.1
Side Clad:	10000.0	328.0	1.0

Source Volume: 2.9044e+6 cm³ 102.568 cu ft. 177238. cu in.

MATERIAL DENSITIES (g/cm³)

Material	Source Shield	Air Gap	Side Clad Shield
Air		0.00122	
Concrete	1.6		1.6
Water	0.3		

BUILDUP

Method: Buildup Factor Tables
 The material reference is Source

INTEGRATION PARAMETERS

	Quadrature Order
Radial	22
Circumferential	22
Axial (along Z)	22

SOURCE NUCLIDES

Nuclide	curies	μCi/cm ³	Nuclide	curies	μCi/cm ³
Ba-137m	3.5792e+003/	1.2323e+003	Co-60	4.3228e+000/	1.4884e+000
Cs-137	3.7835e+003/	1.3027e+003	Eu-154	1.5402e+002/	5.3030e+001

*Microshield is a registered trademark of Grove Engineering, Inc., Rockville, MD. KN

Page : 2
 DOS File: V2.MS4
 Run Date: October 19, 1995
 Run Time: 3:28 p.m. Thursday
 Title : Pool Spill of 5,200 L - Co, Cs and Eu Direct Contribution

===== RESULTS =====						
Energy (MeV)	Activity (photons/sec)	Energy Fluence Rate (MeV/sq cm/sec)		Exposure Rate In Air (mR/hr)		
		No Buildup	With Buildup	No Buildup	With Buildup	
0.1231	2.306e+012	3.270e-001	6.832e+000	5.135e-004	1.073e-002	
0.246	3.892e+011	2.050e-001	2.208e+000	3.771e-004	4.061e-003	
0.4426	5.300e+010	8.450e-002	5.309e-001	1.655e-004	1.040e-003	
0.5907	3.552e+011	9.754e-001	4.841e+000	1.905e-003	9.457e-003	
0.6625	1.207e+014	4.116e+002	1.874e+003	7.978e-001	3.632e+000	
0.8723	7.996e+011	4.580e+000	1.722e+001	8.619e-003	3.240e-002	
1.0024	1.620e+012	1.206e+001	4.151e+001	2.222e-002	7.649e-002	
1.2649	2.269e+012	2.618e+001	7.864e+001	4.599e-002	1.382e-001	
1.3325	1.599e+011	2.035e+000	5.943e+000	3.530e-003	1.031e-002	
1.5767	2.009e+011	3.496e+000	9.388e+000	5.803e-003	1.558e-002	
TOTAL:	1.289e+014	4.615e+002	2.041e+003	8.869e-001	3.930e+000	

MicroSkyshine*

(Nuclear & Radiological Safety Analysis - 1.16-007)
 Page: 1
 File: V1.SKY
 Run: 3:34 p.m.
 : October 19, 1995

File Ref: _____
 Date: _____
 By: _____
 Checked: _____

CASE: Pool Spill of 320,000 L - Co, Cs and Eu Skyshine
 GEOMETRY: Vertical cylinder area source behind a wall

DIMENSIONS (meters):

Distance between wall and detector.....	X	100.
Depth of source behind wall.....	Y	1.5
Offset of detector.....	Z	0.
Depth of dose point.....	H	0.
Distance between center of source and wall... R1		33.4
Thickness of cover slab.....	T1	0.
Thickness of second shield.....	T2	0.
Radius of source.....	W	33.4
Height of source.....	L	0.05

INTEGRATION PARAMETERS:

Number of Radial Segments.....	M	5
Number of Circumferential Segments.....	N	5
Number of Vertical Segments.....	C	16
Quadrature Order.....		16

MATERIAL DENSITIES (g/cc):

Ambient air: .0012

Material	Cover Slab	Lower Shield	Volume Source
-----	-----	-----	-----
Air			
Water			0.3
Concrete			1.6
Iron			
Lead			
Zirconium			
Urania			

Buildup factor based on: WATER.

*Microskyshine is a registered trademark of Grove Engineering, Inc., Rockville, MD. ^{KN}

CASE: Pool Spill of 320,000 L - Co, Cs and Eu Skyshine

SOURCE NUCLIDES:

Nuclide	Curies	Nuclide	Curies
Ba-137m	2.1987e+05 ✓	Co-60	2.5937e+02 ✓
Cs-137	2.3242e+05 ✓	Eu-154	9.4574e+03 ✓

RESULTS:

Group #	Energy (mev)	Activity (photons/sec)	Dose point (rads/photon)	Dose rate (mr/hr)
1	1.30	1.497e+14	3.332e-20	2.058e+01
2	1.02	1.108e+14	3.449e-20	1.575e+01
3	.84	6.425e+13	3.364e-20	8.912e+00
4	.66	7.422e+13	3.456e-20	1.058e+03
5	.48	3.416e+12	3.543e-20	4.991e-01
6	.40	7.328e+11	3.439e-20	1.039e-01
7	.24	2.310e+13	3.165e-20	3.015e+00
8	.20	7.949e+11	2.988e-20	9.793e-02
9	.12	1.416e+14	2.350e-20	1.372e+01
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
TOTALS:		7.917e+15		1.120e+03

MicroSkyshine

(Nuclear & Radiological Safety Analysis - 1.16-007)

Page: 1 File Ref: _____
 File: VZ SKY Date: _____
 Run: 3:37 P.m. By: _____
 : October 19, 1995 Checked: _____

CASE: Pool Spill of 5,200 L - Co, Cs and Eu Skyshine
 GEOMETRY: Vertical cylinder area source behind a wall

DIMENSIONS (meters):

Distance between wall and detector.....	X	100.
Depth of source behind wall.....	Y	1.5
Offset of detector.....	Z	0.
Depth of dose point.....	H	0.
Distance between center of source and wall...	R1	4.3
Thickness of cover slab.....	T1	0.
Thickness of second shield.....	T2	0.
Radius of source.....	W	4.3
Height of source.....	L	0.05

INTEGRATION PARAMETERS:

Number of Radial Segments.....	M	5
Number of Circumferential Segments.....	N	5
Number of Vertical Segments.....	C	5
Quadrature Order.....		16

MATERIAL DENSITIES (g/cc):

Ambient air: .0012

Material	Cover Slab	Lower Shield	Volume Source
-----	-----	-----	-----
Air			
Water			0.3
Concrete			1.6
Iron			
Lead			
Zirconium			
Urania			

Buildup factor based on: WATER.

CASE: Pool Spill of 5,200 L - Co, Cs and Eu Skyshine

SOURCE NUCLIDES:

Nuclide	Curies	Nuclide	Curies
Ba-137m	3.5792e+03	Co-60	4.3228e+00
Cs-137	3.7835e+03	Eu-154	1.5402e+02

RESULTS:

Group #	Energy (mev)	Activity (photons/sec)	Dose point (rads/photon)	Dose rate (mr/hr)
1	1.30	2.442e+12	2.734e-20	2.753e-01
2	1.02	1.807e+12	3.012e-20	2.245e-01
3	.84	1.046e+12	3.023e-20	1.304e-01
4	.66	1.208e+14	3.327e-20	1.658e+01
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
TOTALS:		1.261e+14		1.721e+01

Table A-1. C-106 Radionuclide Inventory Data. (Savino 1994 and Conner 1995a)

Sample type	Drainable interstitial liquid				Sludge/slurry solids				Tank inv.
SAMPLE DATE	05/19/86				05/19/86				05/19/86
Density g/ml					1.43				
Vol. (KGAL)	16				197				213
Vol. (L)	6.06 E+04				7.46 E+05				8.06 E+05
Composite 100 Percentile - Solids (Maximum Sample Activity Concentration)									
Nuclide	Volume Activity (Bq/L)	CEDE Dose (Sv/L)	Contribution (%)	Heat Load (W/L)	Contribution (%)	Lung Dose (Sv/L)	Contribution (%)	Bone Sur Dose (Sv/L)	Contribution (%)
¹² C	1.2 E+04	6.9 E-06	0.0	0.0 E+00	0.0	6.9 E-06	0.0	6.9 E-06	0.0
⁶⁰ Co	3.0 E+07	1.8 E+00	0.0	1.2 E+05	0.1	1.0 E+01	0.1	4.1 E-01	0.0
⁷⁵ Se	0.0 E+00	0.0 E+00	0.0	0.0 E+00	0.0	0.0 E+00	0.0	0.0 E+00	0.0
⁸⁹ Sr	9.7 E+10	6.3 E+03	8.8	3.0 E-03	14.0	3.6 E+02	3.3	7.1 E+04	5.7
⁹⁰ Y	9.7 E+10	2.2 E+02	0.3	1.5 E-02	67.0	9.1 E+02	8.4	1.5 E+00	0.0
⁹⁰ Zr	0.0 E+00	0.0 E+00	0.0	0.0 E+00	0.0	0.0 E+00	0.0	0.0 E+00	0.0
⁹⁹ Tc	1.2 E+07	3.2 E-03	0.0	1.6 E-07	0.0	4.1 E-03	0.0	5.2 E-04	0.0
¹⁰⁶ Ru	0.0 E+00	0.0 E+00	0.0	0.0 E+00	0.0	0.0 E+00	0.0	0.0 E+00	0.0
¹²⁵ Sb	0.0 E+00	0.0 E+00	0.0	0.0 E+00	0.0	0.0 E+00	0.0	0.0 E+00	0.0
¹³⁷ I	4.3 E+03	2.0 E-4	0.0	5.4 E-11	0.0	1.3 E-06	0.0	5.9 E-07	0.0
¹³⁷ Cs	0.0 E+00	0.0 E+00	0.0	0.0 E+00	0.0	0.0 E+00	0.0	0.0 E+00	0.0
¹³⁷ Cs	2.7 E+10	2.3 E+02	0.3	3.4 E-03	15.7	2.4 E+02	2.2	2.1 E+02	0.0
¹³⁸ Ce	0.0 E+00	0.0 E+00	0.0	0.0 E+00	0.0	0.0 E+00	0.0	0.0 E+00	0.0
¹³⁸ Pm	0.0 E+00	0.0 E+00	0.0	0.0 E+00	0.0	0.0 E+00	0.0	0.0 E+00	0.0
¹⁵² Eu	1.1 E+09	8.8 E+01	0.1	2.8 E-04	1.3	9.0 E+01	0.8	6.0 E+02	0.0
¹⁵² Np	0.0 E+00	0.0 E+00	0.0	0.0 E+00	0.0	0.0 E+00	0.0	0.0 E+00	0.0
¹⁵⁴ Pu	1.4 E+08	1.5 E+04	20.5	1.2 E-04	0.6	2.5 E+03	23.5	2.6 E+05	21.0
²³⁹ Pu	3.3 E+08	3.8 E+04	52.9	2.7 E-04	1.2	5.7 E+03	52.2	6.9 E+05	55.2
²⁴⁰ Pu	0.0 E+00	0.0 E+00	0.0	0.0 E+00	0.0	0.0 E+00	0.0	0.0 E+00	0.0
²⁴¹ Pu	2.6 E+09	5.7 E+03	7.9	2.1 E-06	0.0	1.9 E+01	0.2	1.1 E+05	8.6
²⁴¹ Am	5.5 E+07	6.6 E+03	9.2	4.9 E-05	0.2	1.0 E+03	9.3	1.2 E+05	9.5
²⁴³ Am	0.0 E+00	0.0 E+00	0.0	0.0 E+00	0.0	0.0 E+00	0.0	0.0 E+00	0.0
²⁴³ Am	0.0 E+00	0.0 E+00	0.0	0.0 E+00	0.0	0.0 E+00	0.0	0.0 E+00	0.0
²⁴⁴ Cm	0.0 E+00	0.0 E+00	0.0	0.0 E+00	0.0	0.0 E+00	0.0	0.0 E+00	0.0
²⁴⁴ Cm	0.0 E+00	0.0 E+00	0.0	0.0 E+00	0.0	0.0 E+00	0.0	0.0 E+00	0.0
²⁴⁴ Eu	0.0 E+00	0.0 E+00	0.0	0.0 E+00	0.0	0.0 E+00	0.0	0.0 E+00	0.0
Total	2.3 E+11	7.2 E+04		2.2 E-02		1.1 E+04		1.3 E+06*	

* Indicates whole body or organ limited.

PEER REVIEW CHECKLIST

Document Reviewed: 8M400-BEH-95-015, Internal Memorandum to J. C. Conner
 entitled "ESTIMATED DOSE TO ONSITE INDIVIDUAL FROM TANK
 C-106 TRANSFER POOL SPILL".
 Author: Brit E. Hey
 Date: October 19, 1995
 Scope of Review: Entire Document

Yes	No	NA	
<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	Previous reviews complete and cover analysis, up to scope of this review, with no gaps.
<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Problem completely defined.
<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Accident scenarios developed in a clear and logical manner.
<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Necessary assumptions explicitly stated and supported.
<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Computer codes and data files documented.
<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Data used in calculations explicitly stated in document.
<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Data checked for consistency with original source information as applicable.
<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Mathematical derivations checked including dimensional consistency of results:
<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Models appropriate and used within range of validity or use outside range of established validity justified.
<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Hand calculations checked for errors. Spreadsheet results should be treated exactly the same as hand calculations.
<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Software input correct and consistent with document reviewed.
<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Software output consistent with input and with results reported in document reviewed.
<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	Limits/criteria/guidelines applied to analysis results are appropriate and referenced. Limits/criteria/guidelines checked against references.
<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Safety margins consistent with good engineering practices.
<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Conclusions consistent with analytical results and applicable limits.
<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Results and conclusions address all points required in the problem statement.
<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	Format consistent with appropriate NRC Regulatory Guide or other standards
<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	Review calculations, comments, and/or notes are attached.
<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Document approved.

Anthony V. Savino *Anthony V. Savino* 10/20/95
 Reviewer (Printed Name and Signature) Date

United States Government

Department of Energy

Memorandum

Richland Operations Office

DATE: FEB 17 1995
REPLY TO:
ATTN OF: 95-PRI-086

SUBJECT: PRELIMINARY SAFETY EVALUATION REPORT (PSER)

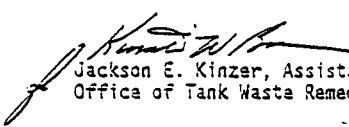
to: J. D. Wagoner

Attached is a Preliminary Safety Evaluation Report (PSER) for Project W-320, 241-C-106 Waste Retrieval Sluicing System. Completion of Project W-320 is included in the Tri-Party Agreement Milestones. This PSER documents the TWRS independent review of WHC's Preliminary Safety Assessment.

DOE Order 5480.23 requires that DOE perform an independent review of the contractor's safety analysis and document that review in a Safety Evaluation Report (SER). The attached represents the first such compliance with that requirement at Hanford. It is our intent that future TWRS projects will also comply with this requirement as we improve our safety oversight responsibilities and integrate safety more fully into the program management process.

Your approval of the attached PSER is recommended.

PRI:OHA


Jackson E. Kinzer, Assistant Manager
Office of Tank Waste Remediation System

95-PRI-

FEB 17 1995

Rec:
 PRI OFF FILE
 PRI RDG FILE
 CCC FILE
 D. ALEXANDER, PRI
 K. BRACKEN, TWR
 W. EDWARDS, PRI
 W. WRZESINSKI, TWP
 SANDERS, TWP
 KRUGER, OSA

RECORD NOTE: NONE

File: PRI:OHA/Prlim.Safety

RECEIVED

FEB 22 1995

DOE-RL/CCC

OFFICE >	PRI <i>Da</i>	PRI	TWP	TWP	OSA	TWR
S. NAME >	ALEXANDER	EDWARDS	WRZESINSKI	SANDERS	KRUGER	KINZER
DATE >	1/23/95	Prev. Concur	Prev. Concur	Prev. Concur	Prev. Concur	<i>EW</i>

(Please Return To Dorothy Watkins, 6-7574, FED/714 BUD)

DOCUMENT No. 48752

SAFETY EVALUATION

Preliminary Safety Evaluation
Project W-320
241-C-106 Waste Retrieval Sluicing System
(WHC-SD-WM-PSE-010, Revision 2; October, 1994)

December 1994

Prepared by: O. H. Alexander *Donald E. Carpenter* 1/10/95
Approved by: *John W. Wayne* 2/17/95

U. S. Department of Energy
Richland Operations Office

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1/22/95
1/10/95
1-10-95

INTRODUCTION

This report provides the U. S. Department of Energy (DOE) Richland Operations Office (RL) preliminary safety evaluation of the proposed sluicing of the nuclear waste in single-shelled, high heat, "watchlist" Tank 241-C-106 (C-106) and transfer of this waste to double-shelled Tank 241-AY-102 (AY-102). This evaluation is based in part on the Preliminary Safety Evaluation (PSE), WMC-SD-WM-PSE-010, Revision 2, dated October 1994, and in part upon independent review meetings and comments. The purpose of this review is to support the safety-related information provided in the Environmental Assessment and to determine whether project planning and system design, construction and testing should be continued as proposed, be modified, or be terminated because of safety considerations. This safety evaluation does not address non-safety related issues which could impact on project success unless those issues also could impact the health and safety of on-site or off-site personnel or the environment.

Because this is a limited-scope evaluation it does not completely conform to the requirements of Attachment 1, Section 4.f of DOE Order 5480.23, nor does the PSE on which it is primarily based. Guidance from DOE Headquarters (HQ; letter, Tseng to Anttonen, July 13, 1993) does not require a new or revised Safety Analysis Report (SAR) for this action. RL, using their Delegation of Authority (letter, O'Toole and Grumbly to Manager, RL; December 9, 1993), has adopted this same guidance as their own. Therefore, a Preliminary SAR will not be required prior to the start of the Waste Retrieval Sluicing System procurement and construction, and a Final SAR will not be required prior to operations. RL will, however, review and approve a Safety Assessment (SA) prior to authorizing waste retrieval operations.

Public Law 101-510, Section 3137 (Wyden Amendment), "Safety Measures for Waste Tanks at Hanford Nuclear Reservation", mandates that the United States Department of Energy develop plans for response to safety issues associated with the waste storage tanks at the Hanford Site, and to report the progress of implementing these plans to Congress. The "Hanford Federal Facility Agreement and Consent Order 89-10", also known as the Tri-Party Agreement, includes milestones to demonstrate single-shell tank (SST) waste retrieval. Milestone M-45-03A, "Initiate Sluicing Retrieval of C-106," by October 1997, requires the retrieval of waste from Tank 241-C-106 to resolve the high-heat safety issue and to demonstrate waste retrieval. Tank 241-C-106 has been identified during the 1994 re-negotiation of the Tri-Party Agreement as the M-45-03 retrieval demonstration tank by the DOE and the Washington State Department of Ecology.

BACKGROUND

Tank C-106 is a 2-million L (530,000-gal) capacity SST. It contains approximately 746,000 L (197,000 gal) of sludge waste. This volume consists of a 91,000 L (24,000 gal) hard-pan layer, 534,000 L (141,000 gal) of high-heat sludge, 121,000 L (32,000 gal) of supernate, and a mineral crust (at the location of a 1986 core sample). The sludge is believed to contain a high concentration of ^{90}Sr , making it the major source of heat. Current heat-generation rate is estimated at 116 MJ/h (110,000 BTU/h), enough to evaporate approximately 23,000 L (6,000 gal) of makeup water per month. The objective of this project is to reduce the heat generation rate to below 42 MJ/h (40,000 BTU/h). Reducing the heat load to this level will allow closure of the tank safety issue.

The postulated safety hazard for the tank without the mitigating effects of the proposed project is high-level nuclear waste release caused by the loss of tank integrity. There are two potential scenarios leading to loss of tank integrity. The first scenario is the inevitable degradation of the tank due to its use well beyond its design life, resulting in a significant tank leak. The second scenario (which may result from the first scenario or other causes) postulates loss of evaporative cooling followed by sludge dryout, resulting in the reinforced concrete overheating and failing. Reflooding of the sludge after dryout could present steam sputtering that would further stress the tank liner and concrete.

It is estimated by Westinghouse Hanford Company (WHC) that without remediation this single shell tank could require cooling water addition until the year 2045. Tank-to-tank sluicing will provide the earliest reasonable closure of this safety concern. Removal of the heat-generating sludge is expected to allow termination of the cooling water addition and permit tank C-106 to be placed into a safe, interim-stabilized state.

This project is to design, fabricate, develop, test, and operate a new retrieval system, the Waste Retrieval Sluicing System. The design objective of the retrieval system is to remove a minimum of 75% of the heat-generating waste in Tank C-106. The proposed design uses double-pipe transfer lines to move sludge from Tank C-106 to AY-102 and to return sluicing fluid from AY-102 to C-106. Two sluicing nozzles will be designed and fabricated for the project. The nozzles will be remotely operated from a control room using visual information from in-tank closed-circuit TV.

This project has identified that radioactive and chemical hazards are available during the construction period. Design and installation will have to account for the existence of these hazards.

EVALUATION

Design and Operation

For the purposes of this evaluation, possibly the most important factor is that the proposed sluicing operation has been completed successfully more than fifty times in the past. This is particularly important because it eliminates the question of whether the sluicing can be conducted safely. Past sluicing operations, particularly those conducted prior to 1960, experienced operational problems, primarily with pump failures. Sluicing operations after that time, using improved pumps, have not experienced similar problems. Line plugging, although it hasn't occurred in the past, is a valid concern. Proposed improved instrumentation should provide early information and reduce this concern.

As proposed, the waste transfer line will be a double-walled pipe and will be designed to conform to DOE Order 6430.1A. Instrumentation will be provided to detect leaks of the inside pipe. While this design would appear to provide improved safety, it is not clear that this approach is the most cost-effective method of enhancing facility safety. Because the most likely pipe rupture mechanism appears to be a seismically initiated failure or other mechanical damage, safety may be enhanced at lower cost by using single-walled piping, designed to the most stringent ASME codes with large seismic design margins. Double-walled piping is particularly useful when corrosion or erosion type failures are a concern; neither should be an issue for this short service life system. However, Washington Administrative Code (WAC) Part 173, Section 303.640, Paragraph 3 requires double containment at all points for this type of operation. The cost and schedule impacts of obtaining a variance from this part of the WAC for this project are not offset by any decrease in risk, but at some later time may be warranted generically for future Hanford Site tank waste retrieval operations.

WMC has stated (letter 94072828 RI, C.A. Augustine to R.L. Long, November 29, 1994) that the Project W-320 pipeline system is designed in accordance with ANSI code 831.3, Chemical Plant and Refinery Piping. This choice was identified as an appropriate code for the project in compliance with the allowance of DOE Order 6430.1A, Section 1300, for the use of comparable safety-related codes. RL agrees that for the low pressure, short life service of this piping, ANSI 831.3 is an appropriate code to satisfy the requirements of DOE Order 6430.1A for the inner piping. RL also agrees that the outer piping, which is primarily a leak collector and spray inhibitor, can be designed to less stringent standards; however, those standards must be clearly identified, justified and carefully followed. We note, however, that the design of the outer piping must be such that it does not allow its existence, operation or failure to degrade the inner piping or limit the inner piping's ability to meet its code requirements. Seismic requirements for both pipes shall be such that it can be shown by analysis that the inner piping will not fail when the entire system is subjected to a Category 1 (0.2g ZPA) earthquake.

At present, all involved tanks (C-106, AY-102 and AY-101) are substantially

SAFETY EVALUATION REPORT: PRELIMINARY SAFETY EVALUATION; PROJECT Y-120,
241-C-106 WASTE RETRIEVAL SLUICING SYSTEM (HNF-SD-WM-PSE-010, Rev 2)

subcritical by both fissile concentration and nuclear poison concentration. The sluicing of C-106, slurry transfer, and dispersal in Tank AY-102 are all mixing type operations which should maintain potential criticality products in dispersed form.

Similarly, this agitating and mixing operation should serve to liberate, rather than capture, formed or released hydrogen during the sluicing and transfer operation. Accordingly, hydrogen build-up during the sluicing and transfer operations should not be a concern. Although hydrogen accumulation during sluicing and transfer should not be an issue, at least four alternative sluicing media other than the one described in the PSE have been proposed. After the transfer operation is completed, the contents of Tank AY-102 may be of a composition that will trap flammable gases, eventually releasing them suddenly into the tank headspace at above the lower flammability limit. The PSE does not discuss this mechanism for the various sluicing fluid options. The SA must, therefore, provide an appropriate analysis and justification for the sluicing fluid chosen, particularly as it affects receiver tank chemistry and the potential for hydrogen retention and subsequent release.

A possible concern is erosion of Tank C-106 during the sluicing operation. To address this issue, WHC proposes to work from the center of the tank outward, impinging sluicing fluid on the tank walls only when the minimum amount of slurry is left in the tank. This appears to be a reasonable approach in the event that sluicing action causes failure of an already weakened tank wall or reopens a tank leak currently plugged by corrosion products or viscous sludge. A related concern is the shock wave or direct shock effect of the sluicing fluid, transmitted to the tank wall and causing mechanical failure. WHC has stated that the design of the sluicing system pumps and nozzles are such that sluicing medium velocity is limited to a degree that this is not a serious concern, but this information is not discussed in the PSE. Limits on sluicing energy must be covered in the SA and associated Technical Safety Requirements.

WHC's preliminary safety evaluation has identified a seismically initiated transfer line break as one of the "event hazardous conditions estimated to be worst case". Their analysis assumes that (for the worst case, unmitigated scenario) pumping continues and a substantial fraction of the tank contents are released to the ground surface. To mitigate the consequences of this accident, they propose a seismic switch, initiated at some nominal ground acceleration, which would shut off the pump and minimize the amount of radioactive material released to the environment. This seismic switch is a fairly simple device which reduces risk during a seismic event; however, it cannot be credited with absolute reliability. The design evaluated in the SA should consider the known reliability of the Safety Class I seismic switches to better demonstrate that the resultant risk is well within the acceptable range.

Conclusion - the proposed design approach appears reasonable, except that systems for transferring tank waste should be analyzed to show their ability to withstand at least a 0.2g ZPA without containment failure.

Accident Analysis

The PSE provides deterministic analyses of a spectrum of postulated accidents. Rough estimates of accident probabilities are presented but not used to calculate quantitative risks. The spectrum of accidents considered appears reasonable, and consequence calculations are adequately, possibly excessively, conservative. Calculations are limited to standard nearest site boundary and 100-meter points. This approach is adequate at this PSE stage because it bounds possible consequences. At the SA stage, accident calculations should use more realistic, although conservative, numbers and should make reasonable estimates of risk in order to better identify necessary safety enhancements. Facility worker safety must also be explicitly addressed.

This PSE assumes that for accidents with unacceptable consequences, use of safety-class equipment or barriers will result in acceptable results, e.g. the seismic switches and the cover blocks on the pump and jumper pits. This is a *de-facto* probabilistic analysis that assumes that the probability of these enhancements failing is sufficiently small to make the overall probability of the event acceptable. This is an acceptable approach at this PSE stage; however, the SA must provide sufficient quantitative information to confirm these assumptions, or additional design (or operational) steps must be taken.

Revision 2 of the PSE provides calculated Effective Dose Equivalents (EDE) for unbounded accidents (beyond OBAs) which are substantially in excess of those allowable by WHC and DOE guidelines, particularly on-site. These EDE's are clearly conservative and not inconsistent with those used for other Hanford projects. As such, they represent an adequate basis for establishing that this project represents no greater bounding hazard than others at the Hanford site. The SA should provide more realistic calculations, including beyond OBAs, to place a better perspective on the overall project risk.

The PSE does not calculate hazard consequences from chemical releases. It does indicate that such consequences are expected to be small when compared with radiological consequences. This is a reasonable position at this PSE stage; however, the SA must provide a complete assessment of potential chemical hazards.

Conclusion - The PSE has identified and analyzed a spectrum of accidents which appear to encompass the proposed project. Calculated consequences from these accidents, without mitigation, range from minimal to unacceptable. Mitigative measures appear to be available to bring all postulated accidents within dose guidelines. More realistic, but still conservative, assumptions should bring these postulated accidents further within guidelines. The use of risk methodology at the SA stage should assure that accidents with lesser consequences don't represent disproportionate risks. As such, the accident calculations provided at this stage in the project appear adequate and the calculated consequences do not preclude continuation with more detailed design and rigorous safety analysis.

REVIEW APPROACH

The review summarized in this evaluation covered a considerable period of time and included numerous experts from national laboratories, RL, RL and HQ support contractors, private industry and consultants. A substantial number of questions, many unrelated to the scope of this evaluation, were raised and resolved. All of the associated questions and resolutions are contained in the review file and are available as required. All of the review information was considered in developing this report.

As this review was being completed, RL recognized the need to develop a more disciplined and complete review process. That process is being implemented on subsequent projects and will be used for the SA on this one; however, it did not seem appropriate or necessary to "start over" on this review. This report does evoke a number of the principles being implemented in this more disciplined and complete review process and provides related guidance so that the SA will be consistent with the new requirements.

Reviewers' comments not covered in this evaluation included: assurance that the necessary heat-bearing materials would be removed by the sluicing, possible foaming of supernata, and potential alternate approaches for retrieval. Although these are all valid issues and responses were provided, they do not directly relate to this evaluation. The more disciplined review procedures to be used for future RL safety reviews will assure that safety reviewers' comments are more properly focused.

It is important to note, that from a safety perspective, failure of this project to accomplish all of its goals is not necessarily negative. At some point, watchlist tanks such as C-106 must be processed, either to reduce their hazard potential or to prevent their leaking. Sluicing and transfer is considered a viable means of performing much of this processing. Lessons learned from this demonstration project will aid in meeting this requirement. Should unexpected results occur, this information can be factored into future designs and operations.

SAFETY EVALUATION REPORT: PRELIMINARY SAFETY EVALUATION; PROJECT W-320,
241-C-106 WASTE RETRIEVAL SLUICING SYSTEM (HNF-SD-WM-PSE-010, REV 2)

RECENT EVENTS

During the period of this review, Tank C-106 has experienced anomalous temperature readings. Cooling water in the tank was deliberately allowed to drop to the level of the sludge (as part of a process test) followed by the addition of about 98,000 L (26,000 gal) of water. Following the water addition, indicated temperature on one of two installed thermocouples slowly rose to some 217°F, dropped to more normal values, and has experienced some oscillations. Although this appears, at worst, to be a local effect, it emphasizes the concerns with leaving Tank C-106 in its current high-heat situation. At this point it does not appear that this recent anomaly should affect the proposed sluicing and transfer operation or the results of this evaluation. Revision 2 of the PSE acknowledges this situation and commits to reporting further details and results of an investigation of it in the upcoming SA for the project.

CONCLUSIONS

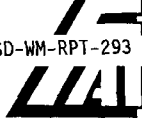
Based on the reviews conducted as summarized in this evaluation, TWRS believes that there is reasonable assurance that Tank 241-C-106 Waste Retrieval Sluicing System project can be designed, procured, constructed, and tested with no undue risk to facility workers, co-located workers, the public, or the environment. In large measure, that conclusion is based on similar past successful operations. From a safety and health standpoint, Project W-320 procurement, construction, and testing are approved. This approval is based on WMC's full compliance with ANSI 831.3 for the inner waste transfer piping for Project W-320, except that quality assurance and record keeping shall be in accordance with DOE Order 5700.6C. Any proposed deviations or variances from the requirements of ANSI 831.3 must be identified, justified and requested in writing to DOE. They shall not be implemented until written approval is received. In no case will deviations or variances be approved if they decrease safety margins or otherwise increase the risk to facility workers, co-located workers, the public, or the environment. The SA must include verification of compliance with 831.3 for the inner piping, identification of the standards used for the outer piping and verification of compliance, and verification that the inner piping can withstand a 0.2g ZPA earthquake including consideration of the behavior of the outer piping and associated supports during this event.

Before a definitive conclusion can be reached on commencement of the proposed waste sluicing and transfer operations, an SA must be completed. This evaluation identifies several issues that must be considered in that SA and which will be assessed in RL's review of the SA:

- Documentation that all piping carrying radioactive or hazardous materials has been designed, procured, and installed to ANSI 831.3 (or ASME B&PV code, Section III). Any deviations or variances must be justified and pre-approved in writing by RL.
- Documentation that all guard piping (outer piping of dual piping)

SAFETY EVALUATION REPORT: PRELIMINARY SAFETY EVALUATION; PROJECT 4-320,
261-C-106 WASTE RETRIEVAL SLUICING SYSTEM (WRC-SD-WM-PSE-010, Rev 2)

- has been designed, procured and installed to clearly identified, written procedures and that the installation, operation, or failure of this piping or its connections shall not compromise the integrity of the inner piping.
- 3 • An analysis (including the influence of the existence and failure of the outer piping) showing that the inner piping can withstand a Category 1 (0.2g ZPA) earthquake without failure.
 - 4 • An appropriate analysis and justification for the sluicing fluid chosen, particularly as it affects receiver tank chemistry and the potential for hydrogen gas trapping.
 - 5 • Provision of limits on sluicing energy as related to potential for mechanical damage to C-106 containment.
 - 6 • Design evaluation using the known reliabilities of the Safety Class 1 seismic switch and other components to better demonstrate quantitatively that the resultant risk is well within the acceptable range.
 - 7 • More realistic yet conservative, calculations, including beyond DBAs, to place a better perspective on overall project risk.
 - 8 • Explicit evaluation of facility worker safety.
 - 9 • Complete assessment of potential chemical hazards.
 - 10 • Investigation, analysis and conclusions regarding the anomalous temperature readings event.



Fauske & Associates, Inc.

DATE: January 12, 1996

TO: John Harris, WHC

FROM: Marty Plys

SUBJECT: C-106 Power Distribution

REFERENCE: T. Bander, Revised Thermal History of Tank 241-C-106, WHC-SD-WM-ER-200, Nov. 9, 1993.

D. Ogden, WHC, personal communication, Dec. 28, 1995.

Independent of the properties of the waste in C-106, it is easily demonstrated that the heat source is not grossly skewed toward the lower hardpan layer of the tank, and that it is probably fairly evenly distributed. The references show that computer modeling is effective for a detailed understanding of the waste temperature distribution, and that the models are in basic accord with observations. The approach taken here is to show what would happen if power were assumed to be skewed toward the hardpan, and to demonstrate that this would conflict with the current understanding of the tank as described by the references.

For C-106, about 90% of the power is lost through the headspace, so the temperature distribution can be fairly represented as one-dimensional for this analysis. For reference, an average temperature drop between 33 to 40 C is observed over a distance of about 6 feet in the soft layer at the riser 8 location. The temperature difference across the softer upper layer(s) due to internal heat generation is given by:

$$\Delta T = \frac{(Q/A)L}{2k}$$

where Q is the power generated in the layer, L is its thickness, and k is its thermal conductivity. In addition, power produced in the lower layer induces a temperature difference in the upper layer of exactly twice the value given by the equation above.

Clearly if all the power were generated in the hardpan, the temperature difference observed and calculated would be much higher than actually observed, so this hypothesis can be quickly discarded. If a fraction F of the power were produced in the hardpan, the ratio of the resulting temperature difference to the nominal temperature difference would be:

$$\frac{\Delta T'}{\Delta T} = \frac{F + 0.5(1 - F)}{0.5}$$

Note that this ratio is independent of the waste properties and depth. If 25% percent of the power were produced in the hardpan, then the value of the ratio is 1.25, i.e., the observed temperature difference would disagree by about 10 C with models assuming little power in the hardpan. While a 10 C discrepancy between observations and calculations could potentially be attributed to factors such as the thermal conductivity or two-dimensional effects (Riser 8 is near the periphery), it would be unrealistic to hypothesize that much more than 25% of the power could be produced in the hardpan.

Therefore, independent of the waste properties in C-106, it can be concluded that most of the power is produced in the soft, upper layer, and that it is unlikely that a substantial fraction of the power is produced in the bottom hardpan layer.



Department of Energy

Richland Operations Office
P.O. Box 550
Richland, Washington 99352

JUL 19 1995

95-RTI-065

President
Westinghouse Hanford Company
Richland, Washington

Dear Sir:

PROJECT 93L-EWW-320, TANK 241-C-106 SLUICING - SLUICING FLUID BASELINE CHANGE TO CORROSION INHIBITED WATER

Reference: Letter from C. A. Augustine, Westinghouse Hanford Company (WHC) to R. L. Long, Department of Energy Richland Operation Office (RL) dated November 2, 1994, Project 93L-EWW-320, Tank 241-C-106 Sluicing - Fluid Baseline Change to Corrosion Inhibited Water

WHC has recommended to RL a change in the baseline sluicing fluid for Project W-320, Tank 241-C-106 Sluicing, to corrosion inhibited water. This change alleviates safety issues identified in the Preliminary Safety Evaluation (PSE) and avoids characterization issues which would be difficult, time consuming, and expensive to resolve.

RL concurs with the WHC recommendation to proceed with use of corrosion inhibited water to sluice tank C-106.

WHC should continue to pursue waste minimization concepts (e.g. use of supernatants, effluents) for waste retrieval operations.

Please contact Wendell Wrzesinski at 376-6751 with any questions on this subject.

Sincerely,

A handwritten signature in black ink, appearing to read "George H. Sanders".

George H. Sanders, Acting Director
Tank Waste Retrieval, Treatment and
Immobilization Division

RTI:NLW

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**Westinghouse
Hanford Company**
**Internal
Memo**

From: Plant Systems Safety Basis 74D10-95-PSSB-KS-036
 Phone: 376-2527 HO-34
 Date: September 20, 1995
 Subject: CURRENT STATUS OF THERMAL HYDRAULIC ANALYSIS AND RESULTS IN
 SUPPORT OF THE SAFETY DOCUMENTATION FOR PROJECT W-320

To: J. C. Conner

~~W1-84~~

H4-68
not at this
ADDRESS

cc: R. J. Cash	S7-15	J. G. Propson	S2-02
B. C. Fryer	HO-34	G. R. Tardiff	S5-05
J. P. Harris, III	S2-48	M. J. Thurgood	HO-34
G. T. Maclean	H5-49	KS File/LB	
D. E. Place	H5-27		

- References:
- (1) Internal Memo, J. C. Conner to D. M. Ogden, "Assistance to be provided by Safety Fluid Mechanics to Project SAR Engineering in Support of the Safety Documentation for Project W-320," dated June 15, 1995.
 - (2) Hanlon B. M., 1995, "Waste Tank Summary Report for Month Ending January 31, 1995," WHC-EP-0182-82, Westinghouse Hanford Company, Richland, Washington.
 - (3) ccMail, Gary R. Tardiff to K. Sathyanarayana dated August 30, 1995.
 - (4) Bander T. J. and M. J. Thurgood, 1995, "Tank 241-C-106 Thermal Hydraulic Analysis to Establish a Minimum Liquid Level," WHC-SD-WM-ER-495, Rev.0, Westinghouse Hanford Company, Richland, Washington.

Purpose:

The purpose of the thermal hydraulic analysis is to provide support (Ref. 1) for the Project W-320, Tank 241-C-106 Sluicing, safety documentation. The analysis has been performed to address two areas of concern. The first item of concern is the safe storage of C-106 sludge in tank AY-102 without considering the operation of air-lift circulators (ALCs). The second item deals with the Criteria for the sluicing activity.

Problem Description:

The proposed sludge transfer from tank C-106 to tank AY-102 will increase both sludge and thermal loading in tank AY-102. The increased sludge and thermal loading will lead to higher sludge temperatures. Tank AY-102, a double-shell tank, which has a design capacity of one million gallons, presently contains 812,000 gallons of waste in the form of supernate and

J. C. Conner
Page 2
September 20, 1995

74D10-PSSB-KS-036

sludge. Based on latest information (Ref.2), the tank contains 32,000 gallons of sludge and 780,000 gallons of supernate. Currently, tank AY-102 is operated with about 600 cfm primary ventilation flow and no secondary (annulus) ventilation flow. Based on the data about ventilation flows, sludge temperature distribution and waste level data, it is estimated that the tank has a heat load of 33,000 Btu/hr. The relevant parameters of the waste in tank AY-102, tank C-106, and the combined waste in tank AY-102 are given in Table 1. Based on the information of Gary Tardiff (Ref.3), it may be possible to provide secondary ventilation flow up to 3,000 cfm for tank AY-102.

Tank C-106, a single-shell tank, which has a design capacity of 530,000 gallons, contains 197,000 gallons of sludge and 22,000 gallons of supernate. Thermal hydraulic analysis (Ref. 4) of tank C-106 1994 - Process Test resulted in an upper bound heat load estimate of 132,400 Btu/hr. The heat distribution in the sludge (Ref. 4) is shown in Table 1. The sludge is represented as three layers with increasing heat loads from top to bottom. The bottom layer of ~2 ft contains a heat source of 64,500 Btu/hr. Currently, the tank is cooled with a primary ventilation flow of about 2,300 cfm.

Results:

Combined sludge temperature distribution calculations are performed using HUB, an engineering calculational software, assuming that a heat load of 92,400 Btu/hr (4.8 ft of C-106 sludge) is transferred to tank AY-102 and the remaining 40,000 Btu/hr (1.2 ft of bottom sludge) will stay in tank C-106. It is also assumed that the sludge from tank C-106 will resettle in tank AY-102 to twice its original thickness (Fluffiness Factor =2). Without the operation of secondary ventilation to cool the tank floor (i.e., an adiabatic boundary condition), the sludge temperatures (See Table 2 for zero cooling effectiveness) will reach local saturation temperature and produce steam if the sludge is a nonconvective medium. With the secondary ventilation cooling available, the peak sludge temperatures can be reduced below saturation if high air flow rates can be obtained. Sludge thermal performance corresponding to two values of secondary ventilation flows of 2,000 and 3,000 cfm have been estimated and the results are shown in Table 2. Calculations were performed to estimate the combined waste temperature distribution versus the effectiveness of secondary ventilation flow. The effectiveness of the ventilation flow is defined as the ratio of actual air temperature rise to maximum possible air temperature rise. The maximum air temperature is that which would occur if the air reached bottom sludge temperature. Figure 1 shows the temperature distribution in sludge for different values of secondary ventilation effectiveness with 2,000 cfm flow. Similar results for 3,000 cfm secondary ventilation flow are shown in Figure 2.

The results show that the peak sludge temperatures will be about 203 and 190 °F with an effectiveness of 35% and flow rates 2,000 and 3,000 cfm, respectively, for the secondary ventilation cooling system. Table 2 also presents the local saturation temperature at the peak temperature location. The lower saturation temperature assumes the liquid in the tank sludge is

J. C. Conner
Page 3
September 20, 1995

74D10-PSSB-KS-036

water and the higher value corresponds to an aqueous solution whose vapor pressure is about 85% of water.

A separate detailed analysis of floor cooling channel effectiveness using the GOTH Computer code was performed to evaluate two-dimensional thermal effects in the sludge near the floor and floor cooling channel. The analysis shows that the effectiveness will be about 37% for 2,000 cfm flow and 32.5% for 3,000 cfm flow. The peak sludge temperature and the secondary ventilation flow floor exit temperature for 2,000 cfm flow are shown in Figures 3 and 4. For 3,000 cfm secondary ventilation flow, these parameters are shown in Figures 5 and 6. For 2,000 cfm secondary flow case, the peak sludge temperature of 204 °F is predicted at 3.75 ft from the tank bottom. The secondary flow with an inlet temperature of 70 °F will enter the cooling channel at the center of the tank bottom and is predicted to exit to the annulus at 107 °F. Using 3,000 cfm secondary flow, the estimated peak sludge temperature is 192 °F at 4.25 ft from the bottom. The secondary ventilation flow is estimated to heat up to 96 °F (See Fig. 7). Therefore, as the results in the Table 2 show, the peak sludge temperature will be about 192 °F with secondary ventilation floor flow of 3,000 cfm and for an assumed inlet air temperature of 70°F. To assure the peak temperature during hot summer conditions will not exceed this value, additional GOTH simulations are being performed using Hanford annual meteorological conditions for the air inflow. This may result in lower peak temperature values than those shown in Table 2 due to thermal inertia effects combined with colder conditions during the winter.

Conclusions:

1. Thermal Effects of Combined Sludge:

The calculations performed using HUB show that the peak sludge temperature of 191 °F at a sludge height of 4.25 ft and 201 °F at a sludge height of 3.75 ft using 3,000 and 2,000 cfm secondary ventilation flow, respectively to cool the tank floor. The GOTH model to evaluate the cooling effectiveness of the secondary flow in the tank floor channels predicts 192 °F and 204 °F peak sludge temperatures with 3,000 and 2,000 cfm secondary flow, respectively. The cooling effectiveness of these cooling air channels at the tank bottom has been estimated to be 32.5% and 37% for 3,000 and 2,000 cfm flow, respectively. The local saturation temperatures range from 236 °F to 246 °F depending on the supernate vapor pressure characteristics and total waste height of 24.5 ft. Therefore, in summary, the transfer of 92,400 Btu/hr waste from tank C-106 to tank AY-102 is acceptable provided the annulus floor ventilation flow can be maintained between 2,000 and 3,000 cfm preferably at the higher level.

2. Criteria for the sluicing activity in C-106:

Sluicing may be initiated in tank 241-C-106 when the following conditions are met after operation of the air chiller system to mitigate any postulated "saturated zone" within the tank.

J. C. Conner
Page 4
September 20, 1995


74D10-PSSB-KS-036

1. The chiller on the tank inlet vent has run long enough to cool the sludge such that the temperature at thermocouple #1 on tree 8 is at or below its normal winter time temperature (148 °F).
2. The behavior of the thermocouples on tree 14 do not contain large random variations in temperature, such as occurred during the process test.
3. Prior to initiating of sluicing, a GOTH simulation will be run with the then current conditions to confirm the nonexistence of the saturation zone.

Sluicing may be continued so long as the following criteria are met:

1. The temperatures on all thermocouples remain below the local saturation temperature.
2. The temperature of thermocouple #1 on tree #8 remains at or below 170 °F.

NOTE: It is very likely, though not certain, that the temperature readings from the thermocouples on tree #14 will start to read high temperatures similar to the readings that occurred following the process test since the sluicing process may wash debris into the annular gap around the tree, disrupting the convective cooling of the tree. This should not cause any concern as long as the temperature readings are below the saturation temperature. If readings at or above saturation temperature are read, continuation of the sluicing process should be reviewed. It is also possible that the temperature readings on tree #8 will increase as there are some indication that some convective cooling of this tree is also occurring and it may be disrupted by the sluicing process. This is acceptable as long as the temperature of 170 °F (the maximum winter temperature predicted by GOTH assuming no gap exists) is not exceeded.


K. Sathyanarayana, Fellow Engineer
Plant Systems Safety Basis

bab

Attachments 2

CONCURRENCE:


D. M. Ogden
Plant Systems Safety Basis

Date: 9/21/95

Table 1. Parameters Used in AY-102 and C-106 Sludge Consolidation.

1. Tank AY-102

Waste Volume: 812,000 gallons (24.57 ft)
 Sludge Volume: 32,000 gallons (0.97 ft)
 Supernatant Volume: 780,000 gallons (23.6 ft)
 Waste Surface Level: 295 inches
 Tank Heat Load: 33,000 Btu/hr

2. Tank C-106

Waste Volume: 219,000 gallons (6.64 ft)
 Sludge Volume: 197,000 gallons (5.97 ft)
 Supernatant Volume: 22,000 gallons (0.67 ft)
 Insoluble Solids Concentration: 48 wt%
 Density of insoluble solids: 100.3 lbm/ft³
 Tank Heat Load: 132,400 Btu/hr (~110,000 +20%)
 Heat Load Distribution:
 Top Layer: 2.78 ft , 22,147 Btu/hr
 Middle Layer: 1.32 ft , 45,738 Btu/hr
 Bottom Layer: 1.87 ft , 64,515 Btu/hr

3. Tank AY-102 with Combined Sludge

1. Sludge

Bottom Layer: AY-102 Sludge, 0.97 ft., 33,000 Btu/hr
 Top Layer: Transferred C-106 Sludge,
 Sludge Height: 9.62 ft
 Fluffiness Factor: 2
 Heat Load: 92,400 Btu/hr (Heat load remained
 in C-106=40,000 Btu/hr)
 Total Waste Volume: 812,000 gallons (24.57 ft)

2. Primary Ventilation

Flow: 630 cfm
 Inlet air Temperature: 70 °F
 Relative Humidity: 50%

3. Secondary Ventilation

Flow: 2000 and 3000 cfm
 Inlet air temperature: 70 °F

Table 2. Tank AY-102 Combined Sludge Peak Temperatures versus Secondary Ventilation Effectiveness.

Secondary ventilation		Peak sludge temperature (°F)		Local saturation temperature (°F)
Effectiveness ↓	Flow → (cfm)	2,000 (cfm)	3,000 (cfm)	
0.0		518	518	243 - 252
0.1		286	253	238 - 248
0.25		220	200	237 - 246
0.35		203	189	236 - 245
1.0		174	168	236 - 245

Figure 1 Temperature Distribution in Sludge Layer of Tank AY-102 with Annulus Ventilation Flow Effectiveness as a parameter for Secondary Vent. Flow of 2000 cfm.

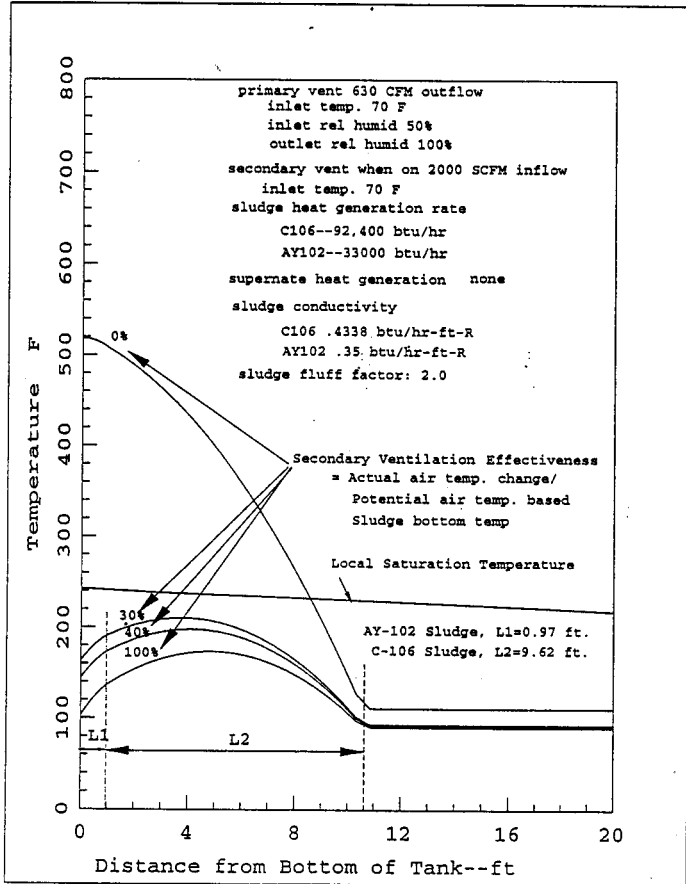


Figure 2 Temperature Distribution in Sludge Layer of Tank AY-102 with Annulus Vent. Flow Effectiveness as a parameter for Secondary Vent. Flow = 3000 cfm.

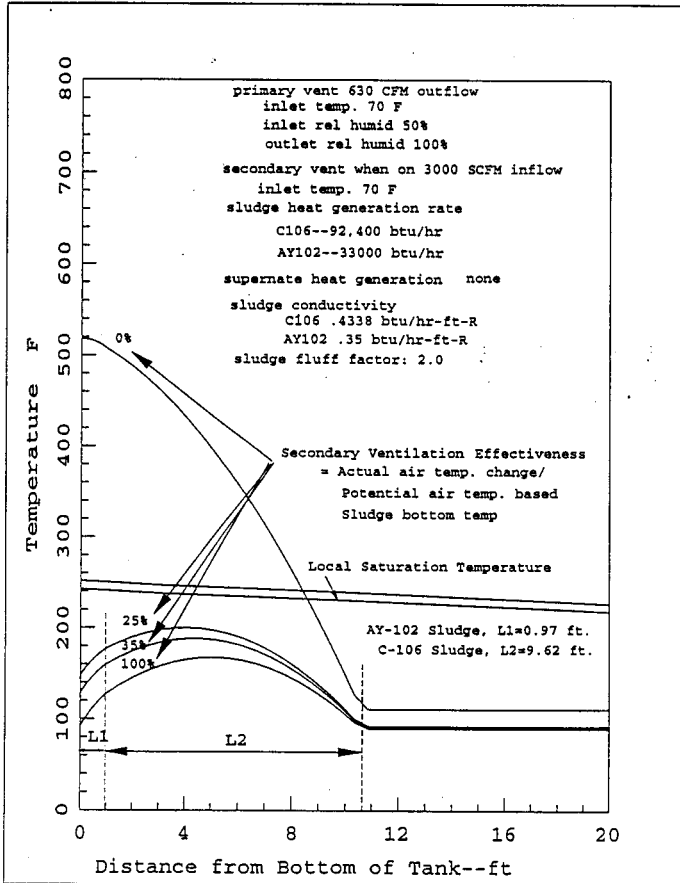
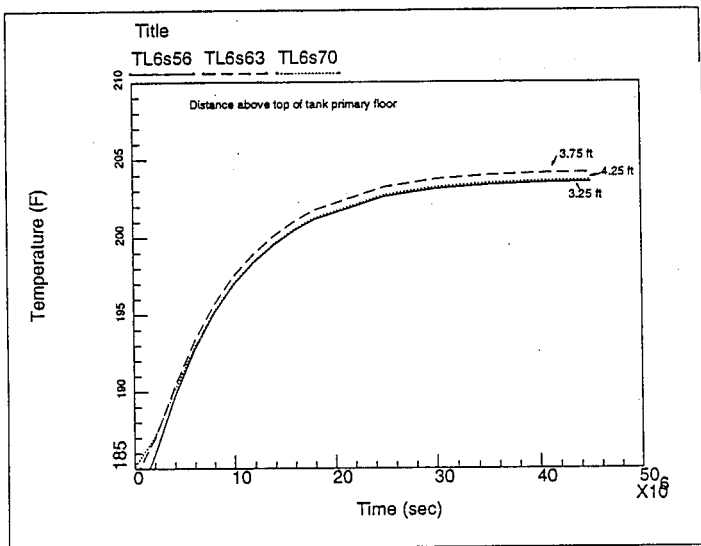


Figure 3. Combined Sludge Peak Temperature for Secondary Ventilation Flow of 2000 cfm.

ay263d3
Tue Sep 19 13:52:35 1995
*GOTH Version 3.4 - April 1991



*GOTH is a trademark of JMI, which is derived from GOTHIC - a registered trademark of the EPRI Corp. of California.

Figure 4. Secondary Ventilation Flow Air Temperature in the Tank Floor Cooling Channel for 2000 cfm Flow.

ay263d3
 Tue Sep 19 13:58:05 1995
 GOTH Version 3.4 - April 1991

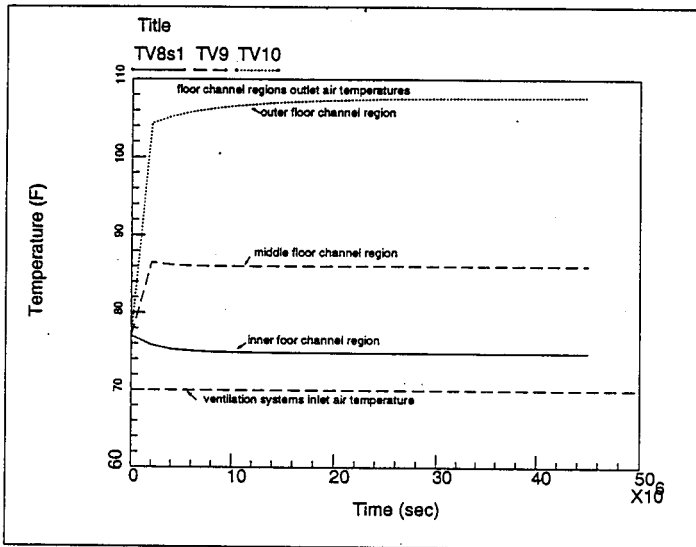


Figure 5. Combined Sludge Peak Temperature for Secondary Ventilation Flow of 3000 cfm.

ay263d4
Tue Sep 19 13:15:59 1995
GOTH Version 3.4 - April 1991

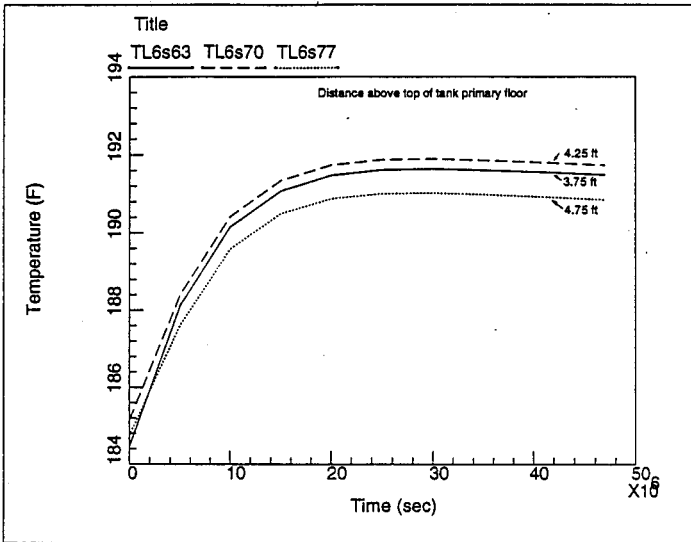


Figure 6. Secondary Ventilation Flow Air Temperature in the Tank Floor Cooling Channel for 3000 cfm Flow.

ay283d4
Tue Sep 19 13:40:42 1995
GOTH Version 3.4 - April 1991

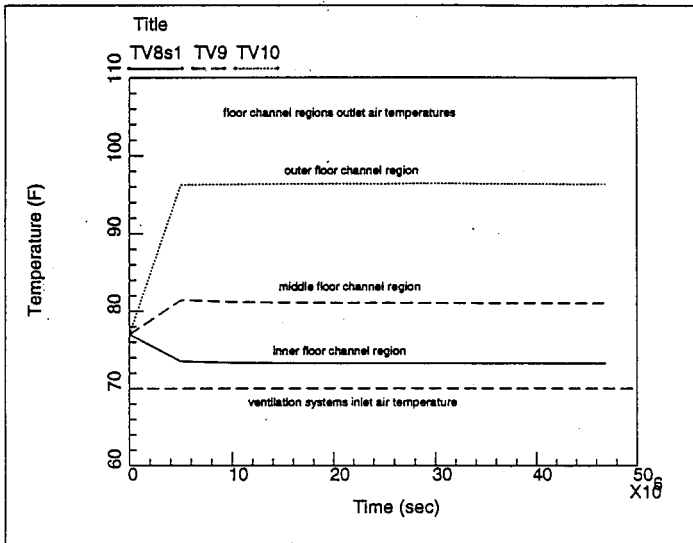
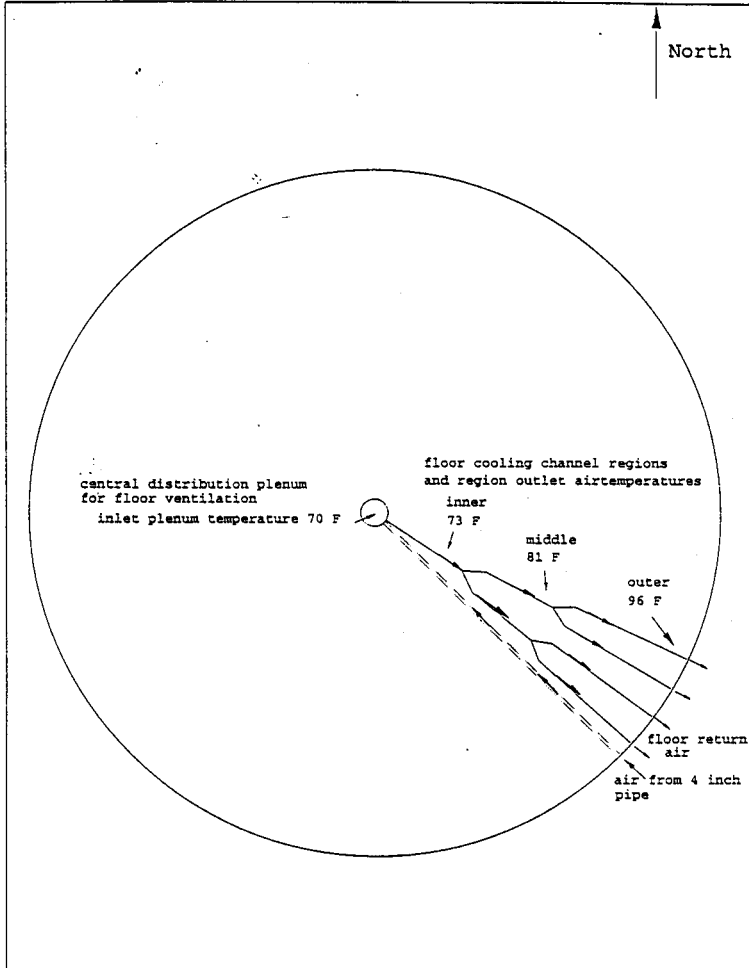


Figure 7. AY-102 Floor Ventilation Channel Regions and Air Outlet Temperatures For 3000 CFM Floor Ventilation Flow at 70 F after a 93400 Btu/hr C-106 Sludge Transfer



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HNF-SD-WM-RPT-293 REV 0
Department of Energy

Richland Operations Office
P.O. Box 550
Richland, Washington 99352

JUN 14 1995

95-TOP-063

President
Westinghouse Hanford Company
Richland, Washington

Post-It™ brand fax transmittal memo 7671		# of pages ▶ 4
To Rankladder	From Guy Bishop	
Co. WHC	Co. RL-TOP	
Dept.	Phone # 372-1856	
Fax # 376-8946	Fax #	

Dear Sir:

RISK ACCEPTANCE CRITERIA FOR TANK FARM OPERATION

Reference: WHC-CM-4-46, "Nonreactor Facility Safety Analysis Manual," Rev 4, March 31, 1995

Westinghouse Hanford Company (WHC) is directed to apply the risk acceptance criteria contained in the enclosure to this letter to all safety analysis for the tank farms and the 242-A Evaporator. Any changes to this criteria will require, at a minimum, concurrence and approval of the changes from my office.

Risk acceptance criteria for the evaluation of the acceptability of accidents at Hanford is contained in the referenced document. The Department of Energy (DOE) has approved application of the criteria taken from earlier revisions of this document for tank farm operation. This was done in the approval of the Evaporator Facility and Above-Ground Transfer Safety Analysis Reports. However, WHC subsequently revised this document in a non-conservative direction. This was done without knowledge or authorization from DOE. By definition, this would constitute an unreviewed safety question when applied to new accidents, as DOE would be asked to assume a greater risk than it has previously accepted for new accidents.

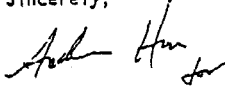
As pertains to tank farm operation, I have concluded that this change is unacceptable.

Therefore, WHC is directed to cease all application of the criteria contained in the updated referenced document for the evaluation of any accidents contained in any safety documents pertaining to any system or equipment in the Hanford Tank Farms, new tank farms, connection systems for the farms, or to the 242-A Evaporator facility. All safety documents pertaining to any system or equipment in the Hanford tank farms, new tank farms, connection systems for the farms or to the evaporator facility will use the criteria enclosed. This includes documents under preparation.

The risk acceptance criteria shown in the enclosure to this letter shall be used for all safety analysis, pending further analysis and concurrence in the revision of this criteria by DOE.

If you have any questions, please contact Mr. Greg Morgan of my staff on
(509) 373-2346.

Sincerely,



Ami B. Sidpara, Director
Tank Operations Division

Enclosure

cc w/encl:
R. Raymond, WHC
J. Lee, WHC
R. Schlosser, WHC
G. Franz, WHC
J. Badden, WHC
D. Busche, WHC
G. Jones, MACTEC

Enclosure

Tank Farm Risk Acceptance Criteria

Radiological Criteria

Range of Annual Frequency	Effective Dose Equivalent (REM)
On-Site Guidelines	
1.0 E-01 to 1.0 E-02 *	1- 5
1.0 E-02 to 1.0 E-04 *	5- 25
1.0 E-04 to 1.0 E-06 *	25- 100
Off-Site Guidelines	
1.0 E+00 to 1.0 E-02 *	.01- .5
1.0 E-02 to 1.0 E-04 *	.5- 4
1.0 E-04 to 1.0 E-06 *	4- 25

- * Note: If a specific single point frequency is used, the guidelines are to be applied as curves. However, if a qualitative frequency ranking is used, the corresponding consequence limit (in REM) shall be used equal to the lowest REM limit for that frequency range.

Toxicological Criteria *

Range of Annual Frequency	On-Site Guidelines	Off-Site Guidelines
1.0 E-02 to 1.0 E+00	≤ ERPG-1	≤ PEL-TWA
1.0 E-04 to 1.0 E-02	≤ ERPG-2	≤ ERPG-1
1.0 E-06 to 1.0 E-04	≤ ERPG-3	≤ ERPG-2

memorandum

DATE:
REPLY TO
ATTN OF:
SUBJECT:

JUL 13 1993

EM-36

Safety Documentation for Tank 241-C-106 Retrieval Operations

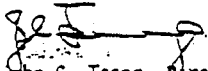
TO:

John Anttonen, Acting Program Manager
Office of Tank Waste Remediation System
DOE Richland Operations Office

This memorandum is being sent to provide guidance in the preparation of safety documentation for Tank 241-C-106 retrieval operations.

For specific operations, such as retrieval of Tank 241-106-C, the safety documentation should: systematically identify the hazards; describe and analyze measures taken to eliminate, control, or mitigate identified hazards; and analyze potential accidents and their associated risks. This documentation (safety assessment) should be prepared in accordance with the attached "Interim Guidance for Preparing safety assessments," dated March 6, 1992. Given our current strategy not to develop supplements to the existing outdated Safety Analysis Reports (SARs), we believe that the safety assessment can serve as an essential step in establishing the safety envelope for Tank 241-C-106. The safety assessment can later be used as a reference document for providing input to the new SAR for Hanford Tank Farms.

The implementation of this guidance would require that Westinghouse Hanford Company (WHC) not prepare supplements to the existing SARs or any new Preliminary or Final Safety Analysis Reports on this issue at this time. In addition, WHC should discontinue unnecessary work on developing SAR chapters at this time and stop development of Limited Scope Safety Analysis Reports when much of the information is incorporated by referencing existing documents.


John C. Tseng, Director
Office of Hanford Programs
Office of Waste Management
Environmental Restoration and
Waste Management

Attachment

cc:
B. Nicoll, DOE-RL
W. Wrzesinski, DOE-RL

Distribution:

bcc:

- EM-361, K. Chacey
- EM-361, J. Mocknick
- EM-361, J. Daly
- EM-362, H. Eckert
- EM-362, D. Gupta
- WHC, N. Croskrey

EM-361:Mocknick:3-5028:mks:7/9/93:a(MOCKNICK) Interim

EM-36 File #2.3.4.3

**previous concurrences are valid

EM-36 Correspondence Reviewer Simon 7/9

EM-361

MOCKNICK

6/28/93 *[Signature]*

EM-362

ECKERT *[Signature]*

6/28/93

EM-361

WYNNE

7/6/93

EM-361

CHACEY *[Signature]*

7/6/93

Westinghouse
Hanford Company

Internal
Memo

From: Radiation Physics and Shielding 22570-HJG-94-005
Phone: 6-3765 HO-35
Date: January 6, 1994
Subject: TANKS 106-C AND 102-AY EQUIPMENT PACKAGING DOSE CONSEQUENCE ANALYSIS FOR SAFETY CLASS ASSIGNMENT

To: D. B. Calmus G2-02
cc: J. G. Field G2-02
J. Greenborg HO-35
R. L. Simons HO-35
S. R. Gedeon HO-35
HJG File/LB

REFERENCES: Internal Memo 22570-HJG-94-001, H.J.Goldberg to D.B.Calmus, "Tanks 106-C and 102-AY Equipment Packaging Dose Consequence Analysis", 7 October 1993

The following analysis is a modification of the analysis referenced above that was developed to support evaluations in the Safety Evaluation for Packaging (SEP) for the 106-C project. The present analysis is to facilitate the assignment of a safety classification to the packages. The release is assumed to be an unmitigated release, and thus 100% of the inventories have been assumed to have been released in the accident scenario. In addition, the onsite worker has been assumed to be 100 m from the accident. These criteria were made to conform to WHC-CM-6-1; Section EP-1.4 Rev. 1, *Standard Engineering Practices; Safety Classification*.

In the previous analysis, the waste was in a solid crystalline form. As per WHC-CM-6-1, 100% of this material was assumed to be released from the shipping container. In order to ascertain the fraction in the respirable range that becomes airborne, the material was assumed to be in a powder form when released. Since the time of the original analysis, several questions have arisen which will be discussed below.

It can be argued that 100% of release from the shipping container does not imply 100% release of the material from the pump surface. This material was washed with a 3,000 psi water spray. While it was decided that no credit would be taken for the cleaning effect of this spray process, it can easily be argued that any material that remains on the pump after this treatment is relatively fixed. It boggles the mind to imagine that material that is so fixed could be completely dislodged by a fall of a meter or so from the shipping container on the back of a truck.

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In addition, only a fraction of these crystals would be crushed to a powder that is respirable ($\leq 1\mu$). An analysis of an FFTF assembly came to the conclusion that, at most, only about 10% of the fuel would be powdered by being crushed between a transport vehicle and a concrete floor. I can dig this number out of the literature, but in the time available for this epistle necessitates that I must rely on my memory.

I would think that, if an accident were to occur, the pump slides out of the damaged container, and a portion of it is crushed by the overturned truck, a conservative estimate of that portion of the attached crystalline material that is removed from the pump might be 50%.

Of this material, it is also quite conservative if we assume that half of that released material is crushed into a powder of a respirable sized particles. The rest will be in the form of larger crystals. While I do not have very much experience with this material and its form on removed equipment, I do recall reading reports about the removal of the air lance from the 101-SY tank.

In that operation, large chunks of material, some solid and some in a more liquid form, fell to the ground. From what I read of the solids in that case it is extremely unlikely that crystals of that size would have become airborne in less than a tornado. In addition it takes an active imagination to imagine a nostril capable of inhaling such chunks.

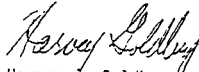
Thus, I would not find it difficult to estimate that 25%-30% of the material were to be released to the ground in the form of particles that are respirable. To this inventory, the previously applied airborne fraction would be available for inhalation by persons standing 100 m from the accident site. With these changes in the parameters of the problem, the doses to a worker and to the maximally exposed farmer are as follows;

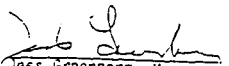
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Effective Dose Equivalent (EDE)		
	Dose to Worker (rem)	Dose to Farmer (rem)
106-C Heel Pump	3.3	0.03
106-C Transfer Pump	0.45	0.0039
102-AY Agitator Pump	2.0	0.036

Thus, it would seem that all of the packages analyzed are in safety class three. This conclusion is based on safety class criteria presented in EP 1.4 indicating that estimated releases less than 0.5 rem for offsite workers and greater than 5 rem for onsite workers are safety class two and releases less than 5 rem to onsite workers are safety class three.


 Harvey A. Goldberg
 Principal Engineer

CONCURRENCE: 
 Jess Greenoorg, Manager
 Radiation Physics and Shielding

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Westinghouse
Hanford Company

Internal
Memo

From: Process Engineering Analysis 74A50-96-BAC-006
 Phone: 376-0205 H0-34
 Date: February 27, 1996
 Subject: TANK C-106 HEAT DISTRIBUTION AND POST SLUICING TEMPERATURES

To: R. J. Cash S7-14

cc: H. Babad S7-14 J. P. Harris, III S2-48
 T. J. Bander H0-34 D. M. Ogden H0-34
 J. C. Conner A2-25 J. P. Sloughter R2-54
 BAC File/LB

- References:
- (1) WHC, Boyless, V. C., 1996, *Operating Specifications for Single-Shell Waste Storage Tanks*, OSD-T-151-00013, Rev. D-10, Westinghouse Hanford Company, Richland, Washington.
 - (2) Fryer, B. C., and M. J. Thurgood, 1995, *Revised Tank Heat Load Estimate for Tank C-206 Based on GOTH Analysis of the Process Test*, JMI-WT002, John Marvin, Inc., Richland, Washington.
 - (3) Ogden, D. M., and K. Sathyanarayana, 1995, *GOTH Tank C-106 Thermal Hydraulic Analysis Related to the 1994 Process Tests*, NAI-940708-3, Numerical Applications, Inc., Richland, Washington.
 - (4) Webb, A. B., et al., 1995, *Preliminary Safety Criteria for Organic Watch List Tanks at the Hanford Site*, WHC-SD-WM-SARR-033, Rev. 0, Westinghouse Hanford Company, Richland, Washington.
 - (5) Gaddis, L. A., 1995, *Supporting Document for the Historical Tank Content Estimate for C Tank Farm*, WHC-SD-WM-ER-313, Rev. 0, Westinghouse Hanford Company, Richland, Washington.
 - (6) Willingham, C. E., 1994, *Thermophysical Properties of Hanford High-Level Tank Wastes - A Preliminary Survey of Recent Data*, PNL-9419, Pacific Northwest Laboratory, Richland, Washington.
 - (7) Bander, T. J. 1993, *Revised Thermal History of Tank 241-C-106*, WHC-SD-WM-ER-200, Westinghouse Hanford Company, Richland, Washington.

INTRODUCTION

Retrieval of tank C-106 waste will be accomplished through Project W-320 in late 1996. The goal of the project is to sluice the tank soft sludge and thereby eliminate the need for water additions or active ventilation cooling. The success of the project depends in part on the heat distribution in the waste. A concern was expressed during the Tier 2 review of Project W-320 that much of the tank heat may be in a non-sluiceable hard pan which could jeopardize the success of the project.

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A study was performed to address this concern. Analyses have shown that for very conservative assumptions for soft waste volume, heat load distribution and dry waste thermal conductivity, sufficient heat can be removed to eliminate the need for further water additions. In addition, using best estimate heat load distributions, which are consistent with the measured tank data, the project will achieve the full project goals.

HEAT LOAD DISTRIBUTION

Heat load estimates for tank C-106 were derived through thermal analyses of the tank and comparison with tank temperature data. Reference 7 gives an estimated heat load of 110,000 Btu/h. This heat is distributed over two regions (0 to 4 feet, 4 to 6 feet). The tank data suggest that the tank heat is skewed toward the bottom with 89% of the heat in roughly 66% of the sludge. A comparison of the results of this model with the Riser 8 thermocouple data is shown in Figure 1. There is excellent agreement for the first three thermal couples. Thermocouple 4 is believed to be near the pool/dome space interface and therefore does not represent a waste temperature.

The heat load estimate for tank C-106 was re-evaluated using a two-fluid computer code, which mechanistically accounted for water evaporation (Reference 2). The revised heat load estimate was 132,400 Btu/h. This heat load estimate was used for all the analyses reported in the following sections. Table 1 summarizes the heat load distributions used for this study. These include the best estimate heat load distribution of Reference 7 and conservative distributions that will be discussed later.

Table 1. Heat Load Distributions.

Distribution	Region 1	Region 2
Best Estimate 132,400 Btu/h total	7.9 Btu/hr-ft ³ (0 - 4 ft)	1.9 Btu/hr-ft ³ (4 - 6 ft)
Conservative Case 1 67,000 Btu/h	9.4 Btu/hr-ft ³ (0 - 2.33 ft)	N/A
Conservative Case 2 130,100 Btu/h	18.4 Btu/hr-ft ³ (0 - 2.33 ft)	N/A
Conservative Case 3 82,400 Btu/h	21.3 Btu/hr-ft ³ (0 - 1.5 ft)	N/A
Conservative Case 4 132,400 Btu/h	34.2 Btu/hr-ft ³ (0 - 1.5 ft)	N/A

Differences in temperature in the waste are an indication of the local heat load distribution within the tank. Figure 2 shows a comparison of the temperature gradients for the Riser 8

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thermocouples with the calculated gradients based upon the heat load distribution of Reference 7. The temperature gradients for heat generation at the surface, heat generation at the bottom, and uniform heat generation are also shown for information. The best estimate heat load is in reasonable agreement with the data from Riser 8.

NON-SLUICEABLE HARD PAN

Concerns for the success of Project W-320 are based on the heat load distribution and the volume of the non-sluiceable hard pan that may exist in the bottom of the tank. Figure 3 shows the tank C-106 sludge level history. The metal bearing waste was added to the tank during the early waste additions (prior to 1965). It is this material that may have formed a hard pan. As shown in Figure 3, the maximum thickness of the hard pan region could be no more than 1.5 feet. This is about 15% of the total waste volume. The historical document suggests that most of the tank heat was added after 1965 (Reference 5). Thus, the hard pan should contain very little heat. Migration of radionuclides into the hard pan may have occurred but could not exceed the best estimate uniform heat distribution.

MODEL DESCRIPTIONS

Scoping Model

Scoping analyses were performed with a one-dimensional model. A solution to Poisson's equation for one-dimensional, steady-state heat conduction was used. The model assumed axial heat conduction with no heat loss from the tank bottom. Heat removal from the dome included heat conduction to the soil and convective heat transfer through the ventilation system.

Detailed Thermal Model

Detailed two-dimensional models were used to confirm the results of the scoping analyses. The primary model employs P/THERMAL, a standard thermal analyses computer code. Models were developed for previous analyses of tank C-106 and are documented in Reference 7. The P/THERMAL model is a two-dimensional finite element model. Two configurations of the model were used. Both were derived from the model documented in Reference 7. One of the models is configured to account for about 75% waste removal (the remaining waste varies from a thickness of 2.33 feet in the center to 1.33 feet at the outside of the tank). This is considered a conservative estimate of the sluiceable sludge. The second model is configured to match the best estimate of the sluiceable sludge (the remaining waste varies from a thickness of 1.5 feet in the center to 0.5 feet at the edge of the tank). The waste conductivities were modified to simulate the conductivity of dry sludge. The model is shown in Figure 4.

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Dry Waste Thermal Conductivity

For a dry waste tank, a major determinant of peak waste temperature is the dry waste thermal conductivity. There are no reported values for thermal conductivity of the waste in tank C-106 that are based on an actual sample of the waste. The values used in the models of References 2 and 7 are based on values that give the best fit to the observed temperature data. These values are consistent with parallel conduction models for conduction in a water sludge mixture. These values are for wet waste and will decrease significantly for dry waste.

Measured thermal conductivities for actual tank waste are documented in Reference 6. These data are shown in Figure 5. The average value of 0.27 Btu/h-ft-°F at 300 °F was selected as the best estimate dry conductivity. The lowest measured value (0.089 Btu/h-ft-°F) was selected as a conservative estimate of the conductivity. The conductivity of tank C-106 hard pan material is expected to be higher than these values since it is compacted with a much smaller porosity than the powders of Reference 6.

TEMPERATURE LIMITS

The temperature limits for tank C-106 are based on the operating specifications for single-shell tanks (Reference 1). The Operational Safety Document (OSD) structural temperature limit is 300 °F in the waste and 350 °F in the concrete.

Organic reactions may be possible if organics are present. However, these reactions normally occur near 390 °F (Reference 4) which is well above the OSD temperature limit.

The 1994 process test and subsequent analyses (Reference 3) demonstrated that tank C-106 operates near saturation temperatures, creating the potential for steam release events. This will not be a concern after sluicing since the remaining material will be hard (non-slucible) and therefore not subject to steam bumps. Steam generated during drying will be released nearly continuously.

Based upon the above considerations, the OSD limit of 300 °F in the sludge was selected as the temperature limit for this study.

RESULTS OF SCOPING ANALYSES

Results from the one-dimensional scoping calculations are shown in Figure 6. The analyses assume waste dryout occurs with ventilation cooling (2300 cfm) only. The analyses were done for the best estimate (BE) and conservative thermal conductivities. The straight lines represent the remaining heat load as a function of remaining waste depth. This is shown for both the best estimate heat load (Table 1) and 2 times the BE heat load. The curved lines are the result of the scoping model for the two thermal conductivities considered. They represent the heat load as a function of remaining waste depth that will result in a maximum waste temperature of 300 °F (OSD limit). The point of intersection of the curves is the maximum waste depth allowed for the assumed thermal conductivity. As an example, for the best estimate heat load and best estimate thermal conductivity, the OSD limit will not be exceeded for waste depths up

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to about 3.25 feet. For the conservative heat load the OSD limit will not be exceeded for waste depths up to about 2.25 feet. For the conservative thermal conductivity, the values are 2 feet and just under 1.5 feet. The non sluicable hard pan is not expected to exceed 1.5 feet in the center of the tank. Thus, these scoping analyses suggest that, both on a best estimate and conservative basis (for both heat load and thermal conductivity), no water additions will be required after sluicing to keep sludge temperatures below OSD limits.

RESULTS OF P/THERMAL ANALYSES

Analyses were performed for two waste retrieval scenarios. The first assumes that 75% of the waste will be removed by sluicing. This is clearly a conservative assumption since the hard pan material as discussed above should be no more than 15% of the waste volume. The best estimate second scenarios assumes that all soft waste is removed by sluicing leaving only a hard pan material of about 15%. The analyses results are presented below.

CONSERVATIVE WASTE REMOVAL

Removal of 75% of the waste by sluicing leaves a depth of 2.33 ft in the center and 1.33 ft at the edge (see Figure 4). Analyses were performed to determine how much heat load could remain without exceeding the OSD temperature limit. The waste was assumed to be dry and heat removal occurred by soil heat conduction and dome ventilation flow of 2300 cfm (no evaporation).

The results are summarized in Table 2. Three heat load distributions were considered as summarized in Table 1. The conservative heat loads were selected so the maximum waste temperatures did not exceed the OSD limits for the two thermal conductivities considered.

Table 2. Results for 75% Waste Removal.

Heat Load Distribution (HLD)	Heat Load (Btu/hr)	Conservative Conductivity (0.089 Btu/hr-ft ² -°F)	Best Estimate Conductivity (0.27 Btu/hr-ft ² -°F)
Best estimate HLD with 2300 cfm ventilation	56,000	264 °F	175 °F
Conservative HLD with conservative conductivity Conservative Case 1	66,600	300 °F	N/A
Conservative HLD with best estimate conductivity Conservative Case 2	130,000	N/A	300 °F

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For the best estimate Heat Load Distribution with full ventilation flow, the maximum waste temperature would be 264 °F for the most conservative conductivity and 175 °F for the best estimate thermal conductivity (Note that the scoping model results discussed in the previous section predict that the OSD limit would be exceeded for a waste depth of 2.33 feet. Because the scoping model is one-dimensional, it does not account for the tank bottom dish nor thermal conduction to the soil through the tank bottom and sides. Thus, as expected the model gives conservative results).

The second analysis establishes the maximum allowable heat load with the conservative conductivity. With 75% waste removal, 67,000 Btu/h could remain in the sludge without exceeding the OSD temperature limit. This is 51% of the total tank heat load.

The third analyses shows the maximum allowable heat load for the best estimate thermal conductivity. A heat load of 130,000 Btu/h or 98% of the total tank heat load could remain after sluicing without exceeding the OSD limit.

A representative temperature contour plot is shown in Figure 7. This temperature distribution is representative of 75% waste removal with a Conservative Case 1 heat load distribution and best estimate thermal conductivity.

The results of both the scoping and P/THERMAL analyses show that for the conservative case of 75% waste removal, the dry waste temperatures can be maintained below OSD temperature limits without evaporative cooling with a significant amount of the total heat load remaining in the waste. These heat load distributions however are clearly not consistent with the measured tank temperature data. The steady-state temperature gradient (prior to sluicing) for the two conservative heat load distributions are compared with actual tank data in Figure 8. The measured temperature difference between TC1 and TC2 for the riser 8 thermocouple tree is less than the temperature difference that would exist for either of the conservative heat load distributions.

The P/THERMAL analyses show that water additions following sluicing will not be required even for very conservative assumptions for waste removal, heat load distribution, and dry waste thermal conductivity.

BEST ESTIMATE WASTE REMOVAL

The analyses of the previous section assumed only 75% waste removal. This is a very conservative estimate. The best estimate for the non-sluciceable hard pan is 15% of the waste volume with a thickness at tank center of 1.5 feet. Analyses were performed with the two-dimensional P/THERMAL model to again demonstrate that a large amount of the tank heat could exist in the hard pan without jeopardizing the success of the project even though such heat load distribution are inconsistent with the tank data. The analyses assumed total waste dryout and were performed for full ventilation (2300 cfm) and ventilation flows representative of passive ventilation flow rates with high tank heat loads (50 cfm). The results are summarized in Table 3. The conservative heat loads were selected so the maximum waste temperatures did not exceed the OSD limits for the two thermal conductivities considered.

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Table 3. Results for Best Estimate Waste Removal.

Heat Load Distribution (HLD)	Heat Load (Btu/h)	Conservative Conductivity (0.089 Btu/h-ft-°F)	Best Estimate Conductivity (0.27 Btu/h-ft-°F)
Best Estimate HLD with 2300 cfm ventilation	32,200	151 °F	106 °F
Best estimate HLD with 50 cfm ventilation	32,200	230 °F	188 °F
Conservative HLD with conservative conductivity Conservative Case 3	82,400	300 °F	185 °F
Conservative HLD with best estimate conductivity Conservative Case 4	132,400	N/A	262 °F

For the best estimate Heat Load Distribution with full ventilation flow, the maximum waste temperature would be 151 °F for the most conservative conductivity and 106 °F for the best estimate thermal conductivity. These temperatures are well below the OSD limits. The heat load of 32,000 Btu/h is also below the 40,000 Btu/h limit for high heat tanks. Thus, the project should be successful in eliminating the tank from the high heat tank list and eliminating water additions.

It should be noted that the best estimate heat load assumes a uniform heat load in the bottom 4 feet of the tank. While the data are sufficient to show that large amounts of heat are not present in the hard pan, the data cannot show that the hard pan is not heat bearing. However, the historical record of tank waste additions suggests that the hard pan should contain little heat. Thus, the actual remaining heat load would probably be less than 32,000 Btu/h.

The second analyses were performed with the best estimate heat load and 50 cfm ventilation flow. This value is comparable to natural convection flows or passive breathing. The analyses indicate the removal of the soft sludge will allow for the elimination of active ventilation with no water additions even assuming conservative values for dry waste thermal conductivity.

The third analyses establishes the maximum allowable heat load with the conservative conductivity. This is Conservative Case 3 in Table 1. With removal of all the soft sludge, 82,000 Btu/h or 62% of the total tank heat load could remain in the sludge without exceeding the OSD limit.

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The fourth analysis shows the maximum allowable heat load for the best estimate thermal conductivity. This is Conservative Case 4 in Table 1. The entire heat load of the tank could remain without exceeding the OSD temperature limit.

The results of both the scoping and P/THERMAL analyses show that for the best estimate waste removal, dry waste temperatures can be maintained below OSD temperature limits without evaporative cooling with a significant amount of the total heat load remaining in the waste. These heat load distributions however are clearly not consistent with the measured tank temperature data. The steady-state temperature gradient (prior to sluicing) for the two conservative heat load distributions are compared with actual tank data in Figure 9. The measured temperature difference between TC1 and TC2 for the Riser 8 thermocouple tree is significantly less than the temperature difference that would exist for either of the conservative heat load distributions.

The P/THERMAL analyses show that water additions and active ventilation following sluicing will not be required even for very conservative assumptions for heat load distribution and dry waste thermal conductivity.

PROJECT GOALS REVISITED

The Project W-320 goals are based in part upon safety and environmental concerns. Because of the heat load of tank C-106, frequent water additions and active ventilation are required to control the waste temperatures below OSD limits. In the event of a tank leak, the drainable liquid would be leaked to the environment and water additions (either bulk or spray) would still be required, which could allow continued leakage. In addition, the 1994 process test demonstrated that steam can accumulate in the waste, thus providing a potential for steam bump events. It needs to be understood that Project W-320 does not need to retrieve all the soft sludge in tank C-106 to reduce the environmental and safety risk associated with a potential tank leak.

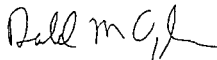
Figure 10 shows the calculated peak waste temperature as a function of waste depth using the best estimate thermal conductivity (0.27 Btu/h-ft²F) of dry waste. The analyses were performed with the P/THERMAL model using the best estimate heat load distribution and full ventilation flow. The analyses show that if the tank leaked and was allowed to dry out with the current water inventory, the temperatures would well exceed the OSD limits. This would create a serious concern for the structural integrity of the tank. Thus, continued bulk water additions or a water spray system would be required to maintain tank cooling. However, if three feet of sludge is removed, the tank temperatures could be maintained below OSD temperature limits

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with ventilation flow only. Removal of any sludge will allow the remaining waste to be cooled more easily. This is due both to heat removal and a shorter conduction path.

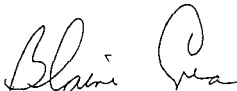
Achieving the full goals of Project W-320 is very desirable, but any waste removal will improve both the environmental and safety risk associated with tank C-106 operations.



D. M. Ogden, Team Leader
Process Engineering Analysis



T. J. Bander, Principal Engineer
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B. A. Crea, Principal Engineer
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bab

Attachment

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ATTACHMENT

FIGURES 1 - 10

Consisting of 6 pages,
including cover page

Figure 1. Riser 8 Temperature Profile for Normal Conditions

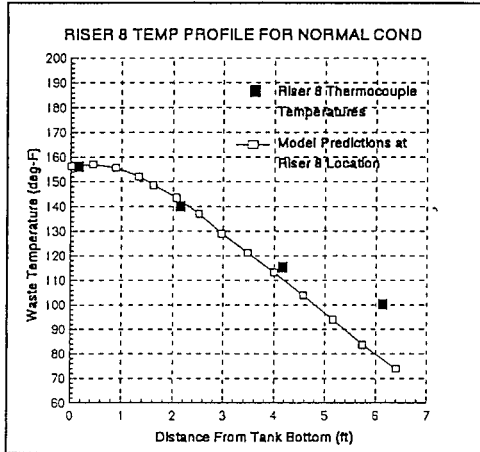


Figure 2. Tank C-106 Temperature Gradients

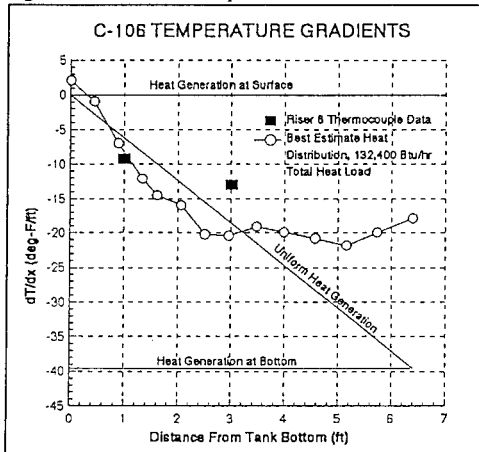


Figure 3. Tank C-106 Fill History

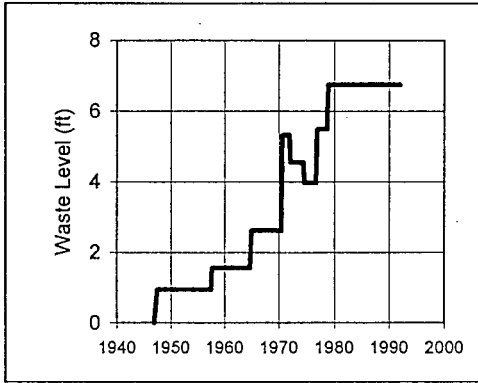


Figure 4. P/THERMAL Finite Element Model.

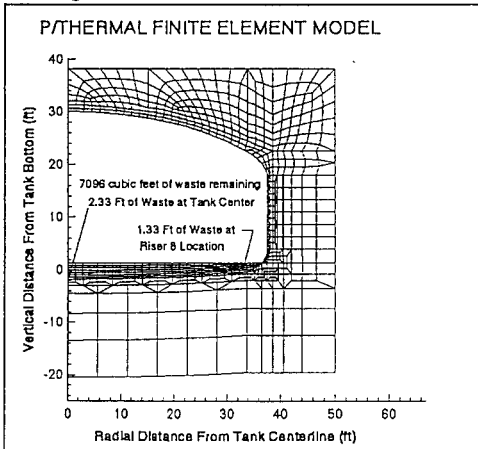


Figure 5. Elevated Temperature Conductivity.

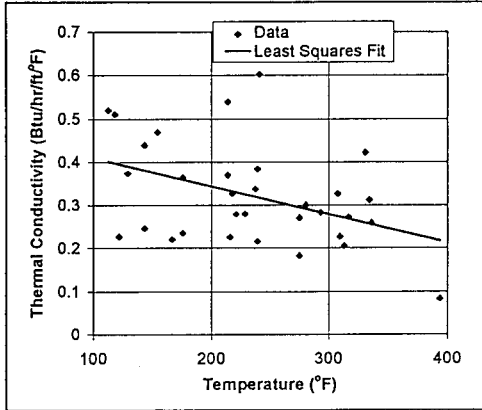


Figure 6. Scoping Model Results.

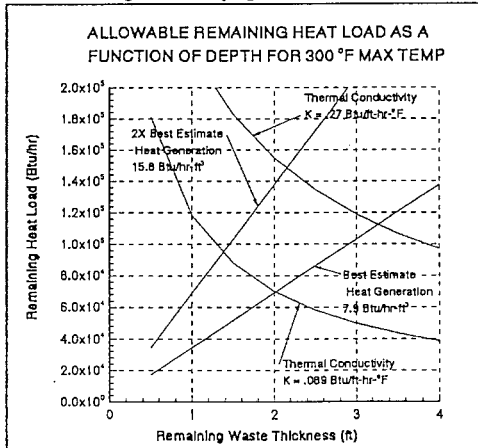


Figure 7. Temperature Distributions After Sluicing.

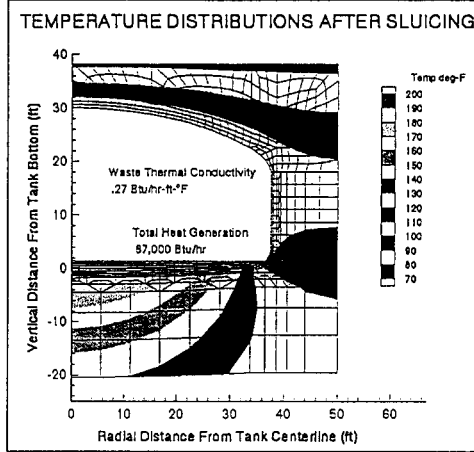


Figure 8. Conservative Waste Removal Compared to Data.

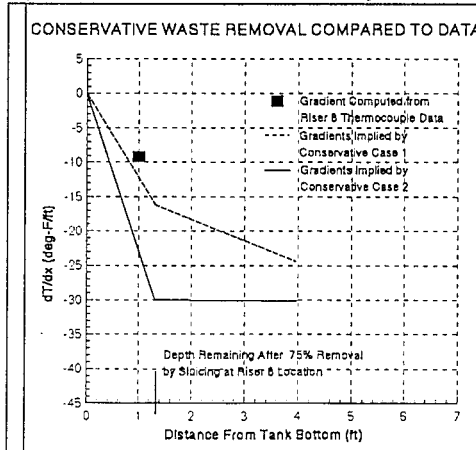


Figure 9. Conservative Heat distribution Compared to Data

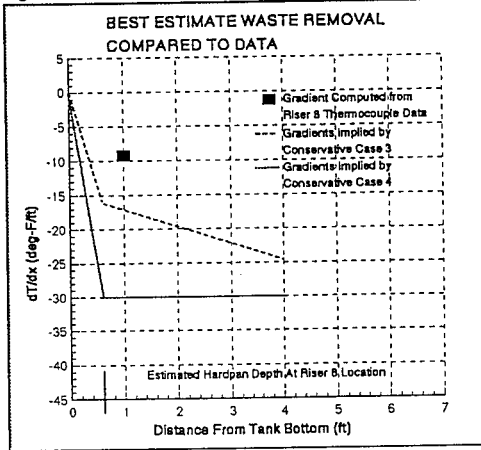
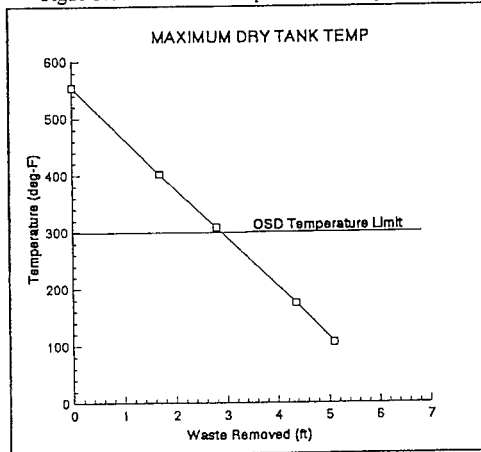


Figure 10. Maximum Temperature for Dry Waste.



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SENT BY:

2- 6-96 : 4:22PM :

FAI - NO. SHORE--

509 376 0546:# 1/ 4



FAX Transmittal

DATE: February 6, 1996
 TO: Mr. John Harris - WHC
 FAX NO.: 509-376-0546
 FROM: Martin G. Plys MGP
 SUBJECT: C-106 "Leading Edge Question" Response

This FAX transmittal equals a total of 4 page(s).

1.0 INTRODUCTION

Dana Powers of the chemical reactions sub-TAP asked whether the leading edge of pumped slurry could freeze or gel as it passes through a cold transfer line. Freezing may be a prior ruled out because the top of pipe of the encasement has an earth cover of 36" and the maximum frost line depth is 30" [1]. Cooling of the leading edge of fluid may occur if the transfer begins when the pipe is cold (but still above 0°C), so salt may precipitate. A straight-forward heat transfer analysis is presented here to estimate the cooldown of slurry fluid and estimate the solid fraction change.

2.0 SUMMARY OF ASSUMED VALUES

The following approximate values are used based on references [1] and [2]:

D	=	0.1 m	4" Line, slight rounded overestimate.
A	=	0.0078 m ²	Corresponding area.
U	=	2 m/s	6 ft/s approximately.
L	=	550 m	1800 ft = 549 km slurry line.
μ	=	0.1 kg/m s	Case of about 30% solids,
	=	0.01 kg/m s	Case of about 10% solids.

16W070 West 83rd Street • Burr Ridge, Illinois 60521 • (708) 323-8750
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SENT BY:

2- 6-96 : 4:23PM :

FAI - NO. SHORE-

509 376 0546:# 2/ 4

FAX: C-106 "Leading
Edge Question" Response

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ρ	= 1100 kg/m ³	Case of about 10% solids.
k	= 0.5 W/m-K	Water value.
c_p	= 2000 J/kg-K	Water value.
W	= 17 kg/s	Derived by $W = \rho UA$.
α	= 2.3×10^{-7} m ² /s	Derived by $\alpha = k/\rho c_p$.
ν	= 9.1×10^{-5} m ² /s	Case of 30% solids by $\nu = \mu/\rho$,
	= 9.1×10^{-6} m ² /s	Case of 10% solids.
Pr	= 400	Case of 30% solids $Pr = \nu/\alpha$,
	= 40	Case of 10% solids.
Re	= 2200	Case of 30% solids $Re = UD/\nu$,
	= 22,000	Case of 10% solids.
P	= 0.31 m	$P = \pi D$.
T_0	= 27°C	80°F approximately.
T_w	= 1°C	Above freezing, conservatively low.

3.0 TEMPERATURE DROP ANALYSIS

Using the data listed in the "Summary of Assumed Values" and following symbols listed in "Nomenclature" the slurry line Reynolds number may take on values between 2200 and 22000 for 30% and 10% solids, respectively, so that turbulent flow should be expected for the leading edge. The heat transfer coefficient is given approximately by:

$$Nu = \frac{hD}{k} = 0.023 Re^{0.4} Pr^{0.8} \quad (1)$$

from which $h = 300$ W/m²K for 30% solids and $h = 120$ W/m²K for 10% solids.

The temperature change of the fluid along the transfer line is given by:

$$\frac{T - T_w}{T_0 - T_w} = \exp \left[- \left(\frac{hP}{Wc_p} \right) L \right] = \exp (-\lambda L) \quad (2)$$

So for 30% solids $\lambda L = 1.5$, and for 10% solids $\lambda L = 0.60$. Thus, the final fluid temperatures are 7°C and 15°C for the two cases, respectively.

SENT BY:

2- 6-96 : 4:24PM :

FAI - NO. SHORE-

509 376 0546:# 3/ 4

FAX: C-106 "Leading
Edge Question" Response

Page 3

February 6, 1996

4.0 PRECIPITATION POTENTIAL

From [3] the concentrations of important salts in C-106 solution are:

NO ₃	67 g/L	NaNO ₃ equivalent 92 g/L.
OH	2 g/L	NaOH equivalent 3.5 g/L.
PO ₄	4.4 g/L	Na ₃ PO ₄ equivalent 7.6 g/L.
SO ₄	5.0 g/L	Na ₂ SO ₄ equivalent 7.4 g/L.

Lacking solubility data for such a mixture, a heuristic approach is to assume an equivalent of 120 g/L NaNO₃, which exceeds the sum of salt concentrations. The ratio of interest for solubility is:

$$\frac{\text{g Nitrate}}{\text{g Water}} = \frac{\text{g/L Nitrate}}{\text{g/L Solution} - \text{g/L Nitrate}} = \frac{120}{1180 - 120} = 0.11 \quad (3)$$

where it is assumed that other compounds have negligible concentration by comparison.

The solubility limit of NaNO₃ is about 0.037 g NaNO, 1 g H₂O at 0°C and 0.178 at 25°C [4]. By linear interpolation, the solubility limits at 7°C and 15°C are 0.077 and 0.12 g NaNO, 1 g H₂O, respectively.

Since the C-106 sludge and interstitial solution will be diluted by sluicing water, it is clear that a figure below 0.05 g NaNO, 1 g H₂O is better representative of the pumped slurry than the actual C-106 value. Hence, no precipitation of slurry salts would be expected.

5.0 NOMENCLATURE

A	Pipe area, m ² ,
c _p	Specific heat of fluid, J/kg·K,
D	Pipe diameter, m
h	Heat transfer coefficient, W/m ² K,
L	Pipe length, m
Nu	Nusselt number,
P	Pipe wall perimeter, m,
Pr	Prandtl number,

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2- 6-96 : 4:24PM :

FAI - NO. SHORE-

509 376 0546:# 4/ 4

FAX: C-106 "Leading
Edge Question" Response

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February 6, 1996

Re Reynolds number,
T Fluid temperature, K,
 T_0 Initial fluid temperature, K,
 T_w Wall (pipe) temperature, K,
U Fluid speed, m/s,
W Fluid mass flowrate, kg/s,
 α Thermal diffusivity, m^2/s ,
 ρ Density, kg/m^3 ,
 μ Viscosity, $kg/m \cdot s$,
 ν Kinematic viscosity, m^2/s , and
 λ Inverse length for temperature profile, m^{-1} .

6.0 REFERENCES

- [1] D.L. Evans, WHC internal memorandum to T.H. May, W-320s Process Transfer Lines, Physical Data, January 26, 1996.
- [2] Tom May, WHC, personal communication.
- [3] Bruce Castaing, 101-AY, 102-AY, and 106-C Data Compendium, WHC-SD-WM-TI-578, Rev. 1.
- [4] International Critical Tables, p. 372.

MGP:vdI

02/12/96 17:35

☎ 509 376 0546

MO-294/200 EAST --- S.A.P. MANAG-MT

② 002



Fauske & Associates, Inc.

DATE: February 8, 1996

TO: John Harris and Bob Cash, WHC 509-376-0546

FROM: Marty Plys *M. Plys*

SUBJECT: Response to C-106 "Trailing Edge" Question

Dana Powers of the Chemical Reaction sub-TAP asked whether slurry solids in the transfer line would settle out when pumping is stopped and flow reverses. By examining the fallout velocity for large slurry particles, we may show that little settling would be expected during the flow reversal and spillback time. According to [1], about 25% of the particle mass is found between 40 and 55 microns, with 45 micron being roughly the average diameter of this size bin. Also from [1], the mixture viscosity increases from 4 cP (0.004 kg/m.s) for clear liquid (water) to 13 cP at 10% solids loading and 105 cP at 30% solids loading. Clearly the large increase in viscosity is due to the abundance of small particles, corroborated by 35% of the mass belonging to particles below 10 micron size. The small particles simply cannot fall out during operations, and act to impede the fallout of the large particles.

Thus, fallout of the large particles can be treated as if the mixture viscosity acts upon them. The case of 10% solids loading will be considered here because fallout times for the 30% loading case would be ten times longer. The Stokes law terminal velocity for a 45 micron particle of density 1720 kg/m³ in fluid with a density of 1000 kg/m³ and viscosity 0.013 kg/m.s is 0.06 mm/s. This means that during the fluid velocity reversal time on the order of 10 seconds or less, the largest particles would fall less than 1 mm, or less than 1% of a pipe diameter. Therefore, during the time period when bulk fluid velocities in the pipe may be low, very little settling can occur.

Indeed, during the reverse flow drainage time which is less than 10 minutes, these particles would only fall about 30% of the pipe diameter. Note that particles that could fall out during transfer line reverse flow drainage could also be reentrained. While methods exist to predict the batch settling of particles more precisely, as a heuristic rule for this example we can state that less than 50% of the large particles, representing about 12% of the total suspended mass, could potentially fall out in this case, which means that the total solids fraction would change from 10% to 9%. Simply put, there will not be enough solid fallout to block a pipe.

[1] Tom May, Westinghouse Hanford Company, personal communication, 1/24/96.

16W070 West 83rd Street • Burr Ridge, Illinois 60521 • (708) 323-8750
Telefax (708) 986-5481

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03/01/96 10:52
SENT BY:

☎ 509 376 0546

MO-294/200 EAST

--- S.A.P. MANAG-MT

☑ 002

2-28-96 : 3:24PM :

FAI - NO. SHORE-

509 376 0546:# 1/ 1



Fauske & Associates, Inc.

16W070 West 83rd St., Burr Ridge, IL 60521

FAX: (708) 986-5481 • Phone: (708) 323-8750 • email: fai@xnet.com

DATE: February 28, 1996.

TO: John Harris, WHC

FAX NO.: ⁵⁰⁹
~~509~~-376-0546

FROM: M. G. Plys *MGP*

SUBJECT: C-106 3-Phase Flow

REFERENCES:

- 1) Hopkins, J. D., Flammable Gas Evaluation of Tank 241-C-106, WHC Internal Memo, February 26, 1996.
- 2) Collier, J. G., Convective Boiling and Condensation, McGraw-Hill, 1981.
- 3) Tom May, Westinghouse Hanford Company, personal communication, 1/24/96

This FAX transmittal equals a total of 1 page(s).

According to Hopkins, Reference 1, the stored gas volume fraction in C-106 waste is about 2%. If this gas is retained as large bubbles, it may be released in the tank during sluicing, while if it is retained as small bubbles, it may be pumped with sluicing liquid. At such a low volume fraction, the gas will be transported as a bubbly or intermittent plug flow if the bubbles can coalesce (see any two-phase flow reference such as Ref. 2). There is no reason to suppose that the presence of this small quantity of gas would cause settling of suspended solids, most of whose mass is represented by particles below 40 micron size (indeed 35% of the mass is below 10 micron size, Ref. 3).

MGP:jgk

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**Westinghouse
Hanford Company**
**Internal
Memo**

From: Process Engineering Analysis 74A50-96-BAC-003
 Phone: 376-0205 HO-34
 Date: February 1, 1996
 Subject: RESOLUTION OF PROJECT W-320 TIER 2 REVIEW COMMENTS

To: R. J. Cash S7-14

cc: H. Babad S7-14
 J. C. Conner A2-25
 J. P. Harris, III S2-48
 D. M. Ogden HO-34
 J. P. Slaughter R2-54
 BAC File/LB

INTRODUCTION

Engineering analyses has been performed to address specific comments resulting from the Tier 2 review of Project W-320 (Tank C-106 retrieval). The following questions have been identified by the Technical Advisory Panel, Chemical SubTap (J. L. Kovach letter, dated November 10, 1995):

- Would the remnants of the waste in tank C-106 still require water addition to prevent waste dry-out, or would the waste be permitted to dry out?
- If tank C-106 remnants are left to dry out, would there be an aggravation of the potential organic condensed phase reaction problem?
- Is it considered that tank C-106 may require humidification or other means of water addition after the 75% waste removal?

The peak waste temperatures following the Project W-320 sluicing operation is dependent upon the quantity of tank waste removed, the spatial distribution of the tank heat and the thermal conductivity of the "dry hardpan" remaining.

The purpose of this letter is to summarize the results of an engineering study which evaluated the above issues. Parametric analyses were performed for the tank heat load distribution and waste conductivity. The study determined the minimum fraction of heat that must be removed as a function of remaining waste thickness to maintain the tank waste below applicable temperature limits without the continued addition of cooling water.

MODEL DESCRIPTIONS

Scoping analyses was performed with a one dimensional model. A solution to Poisson's equation for one dimension, steady state heat conduction was used with the following assumptions:

- Energy removal by convection only from the waste surface

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- No heat loss from the tank bottom
- Dome ventilation at current levels (2300 cfm).

Detailed two-dimensional models were used to confirm the results of the scoping analyses. The primary model employs P/THERMAL, a standard thermal analyses computer code. Models were developed for previous analyses of tank C-106 and are documented in Reference 1. The P/THERMAL model, shown in Figure 1, is a two dimensional finite element model. The model was modified from the model documented in Reference 1 to account for about 75% waste removal (the remaining waste varies from a thickness of 2.33 feet in the center to 1.33 feet at the outside of the tank) and waste conductivities were modified to simulate the conductivity of dry sludge.

Both the one- and two-dimensional models used a total tank heat load of 132,400 Btu/hr as recommended by Reference 3. The basic heat load distribution was however derived based on a model with a tank heat load of 110,000 Btu/hr (Reference 1). A comparison of the results of this model with the Riser 8 thermocouple results is shown as Figure 2. The heat load distributions used for the study are summarized in Table 1. The best estimate distribution with 110,000 Btu/hr total best fits the Riser 8 thermocouple data. The conservative heat load distributions will be discussed in the results section.

Table 1. Heat Load Distributions.

Distribution	Region 1	Region 2
Best Estimate 110,000 Btu/hr Total	6.3 Btu/hr-ft ³ (0 - 4 ft)	1.5 Btu/hr-ft ³ (4 - 6 ft)
Best Estimate 132,400 Btu/hr Total	7.9 Btu/hr-ft ³ (0 - 4 ft)	1.9 Btu/hr-ft ³ (4 - 6 ft)
Conservative Case 1 67,000 Btu/hr	9.4 Btu/hr-ft ³ (0 - 2.33 ft)	N/A
Conservative Case 2 130,100 Btu/hr	18.4 Btu/hr-ft ³ (0 - 2.33 ft)	N/A

Differences in temperature gradients in the waste are an indication of the local heat load distribution. Figure 3 shows temperature gradients. The temperature gradients for heat generation at the surface, heat generation at the bottom and uniform heat generation are shown for reference. The best estimate is based upon the Reference 1 distribution using the Reference 3 total heat load. It is in good agreement with the data from Riser 8 for the lower portion of the tank.

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February 1, 1996

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DRY WASTE THERMAL CONDUCTIVITY

For a dry waste tank, a major determinant of peak waste temperature is the dry waste thermal conductivity. There are no reported values for thermal conductivity of the waste in tank C-106 that are based on an actual sample of the waste. The values that are used in the models documented in References 1 and 3 are based on values that give the best fit to the observed temperature data. These values are consistent with parallel conduction models for conduction in a water sludge mixture. These values are for wet waste and will decrease significantly for dry waste.

Measured thermal conductivities for actual tank waste are documented in Reference 2. This data is shown in Figure 4. The average value of 0.27 Btu/hr-ft-°F at 300 °F was selected as the best estimate dry conductivity. The lowest measured value (0.089 Btu/hr-ft-°F) was selected as a conservative estimate of the conductivity. The conductivity of tank C-106 "hardpan" material is expected to be higher than these values since it is completed with a smaller porosity.

TEMPERATURE LIMITS

The temperature limits for tank C-106 are based on the operating specifications for single-shell tanks (Reference 4). The Operational Safety Document (OSD) structural temperature limit is 300 °F in the waste and 350 °F in the concrete. Organic reactions may be possible if organics are present. However, these reactions normally occur near 390 °F (Reference 5) which is well above the OSD temperature limit. Therefore, the OSD limit of 300 °F in the sludge was selected for this study (analyses have shown that the concrete temperatures are lower than the sludge temperatures).

ANALYSIS RESULTS

Results from the one-dimensional scoping calculations are shown in Figure 5. The results show the heat load that can remain after sluicing and not exceed the OSD limit of 300 °F. The analyses was done for the best estimate (B.E.) and conservative thermal conductivities. The straight lines represent the heat load distribution for the best estimate heat load (Table 1) and 2 times the best estimate heat load. With the B.E. conductivity and heat load, 3.25 ft of sludge could remain, it would have a 115,000 Btu/hr heat load. With the conservative conductivity and heat load distribution, less than 1.5 ft of sludge could remain, it would have a 100,000 Btu/hr heat load. The hard pan region is thought to be on the order of 1 foot thick, and based on the historical tank data should not contain much of the tank heat load. These analyses therefore suggest that both on a best estimate and conservative basis, no water additions will be required after sluicing to keep sludge temperatures below OSD limits.

R. J. Cash
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Analyses were also performed with the two-dimensional P/THERMAL model. Seventy five percent of the waste was assumed to be removed by the sluicing operation. This gave a depth of 2.33 ft in the center and 1.33 ft at the edge (see Figure 1). Analyses were performed to determine how much the tank heat load could remain without exceeding the OSD temperature limit. The waste was assumed to be dry and heat removal occurred by dome ventilation flow of 2300 cfm (without evaporation) and soil heat conduction.

The results are summarized in Table 2. Three heat load distribution were considered as summarized in Table 1. The conservative heat loads were selected so the maximum temperatures did not exceed the OSD limits for the two thermal conductivities considered.

Table 2. Results of P/THERMAL Analyses.

Heat Load Distribution	Heat Load (Btu/hr)	Conservative Conductivity	Best Estimate Conductivity
Best Estimate	56,000	264 °F	175 °F
Conservative Case 1	67,000	300 °F	193 °F
Conservative Case 2	130,000		300 °F

For the best estimate case, the maximum temperature would be 264 °F for the most conservative conductivity. Assuming the best estimate thermal conductivity, 130,000 Btu/hr could remain in the sludge. This is 98% of the total tank heat load. A heat load of 67,000 Btu/hr or 51% of the total tank heat load could remain for the most conservative thermal conductivity (The one-dimensional model (Figure 5) for a 2.33 ft waste depth gives a values lower than the P/THERMAL model. This is expected because of the nonuniform waste depth and conduction losses from the tank bottom).

A representative temperature contour plot is shown in Figure 6. This temperature distribution is representative of a Conservative Case 1 heat load distribution combined with the best estimate thermal conductivity.

The results of both the scoping and P/THERMAL analyses show that for 75% waste removal, the dry waste temperatures can be maintained below OSD temperature limits without evaporative cooling with a significant amount of the total heat load remaining.

The steady-state temperature gradient (prior to sluicing) for the two conservative heat load distributions are compared with actual tank data in Figure 7. While the OSD temperature limits will not be exceeded with these conservative heat load distributions, they are clearly inconsistent with the Riser 8 data.

R. J. Cash
Page 5
February 1, 1996

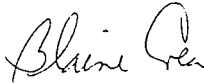
74A50-96-BAC-003

CONCLUSIONS

Tank C-106 waste temperatures will not exceed the OSD temperature limits following Project W-320 waste retrieval and evaporative cooling, and continued water additions will not be required.

REFERENCES

1. Bander, T. J., 1993, *Revised Thermal History of Tank 241-C-106*, WHC-SD-WM-ER-200, Westinghouse Hanford Company, Richland, Washington.
2. Willingham, C. E., 1994, *Thermophysical Properties of Hanford High-Level Tank Wastes - A Preliminary Survey of Recent Data*, PNL-9419, Pacific Northwest Laboratory, Richland, Washington.
3. Fryer, B. C., and M. J. Thurgood, 1995, *Revised Tank Heat Load Estimate for Tank C-106 Based on Goth Analysis of the Process Test*, JMI-WT002, John Marvin, Inc., Richland Washington.
4. WHC, Boyless, V. C. 1995, *Operating Specifications for Single-Shell Waste Storage Tanks*, OSD-T-151-00013, Westinghouse Hanford Company, Richland, Washington.
5. Webb, A. B., et al., 1995, *Preliminary Safety Criteria for Organic Watch List Tanks at the Hanford Site*, WHC-SD-WM-SARR-033, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

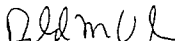


B. A. Crea, Principal Engineer
Process Engineering Analysis

bab

Attachments 2

CONCURRENCE:



D. M. Ogden, Team/Leader
Process Engineering Analysis

Date 2/2/96

74A50-96-BAC-003

ATTACHMENT

FIGURES 1 - 7

Consisting of 5 pages,
including cover page

Figure 1. P/Thermal Finite Element Model.

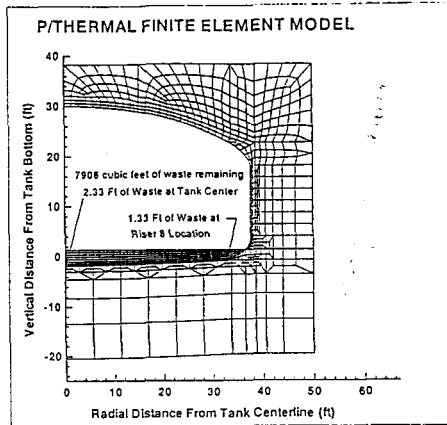


Figure 2. Riser 8 Temperature Profile for Normal Conditions (110,000 Btu/Hr)

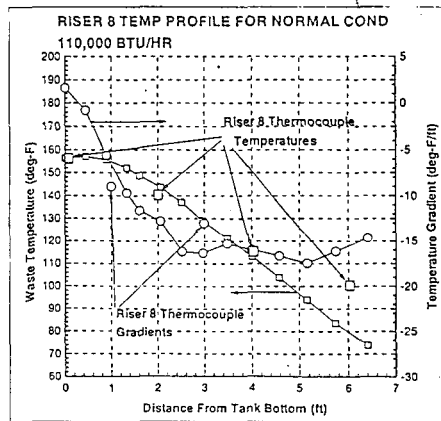


Figure 3. C-106 Temperature Gradients.

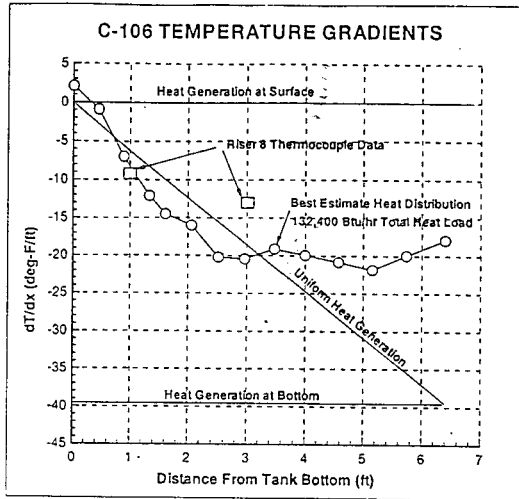


Figure 4. Elevated Temperature Thermal Conductivity. (Reference 2)

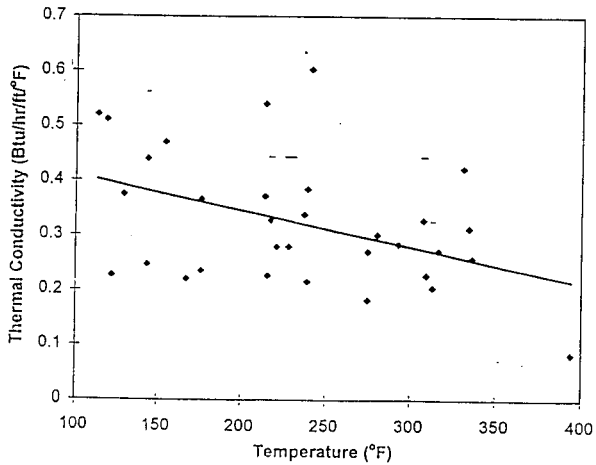


Figure 5. Allowable Remaining Heat Load as a Function of Depth for 300 °F Maximum Temperature.

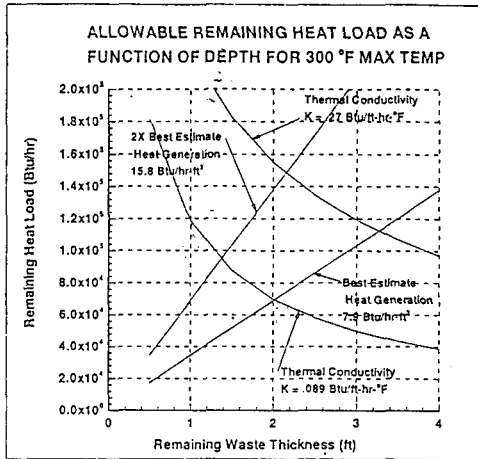


Figure 6. Temperature Distributions After Sluicing.

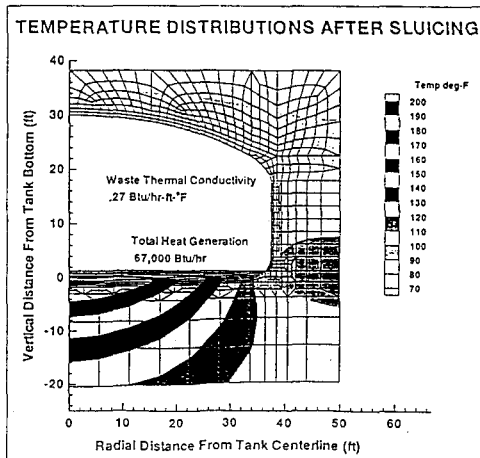
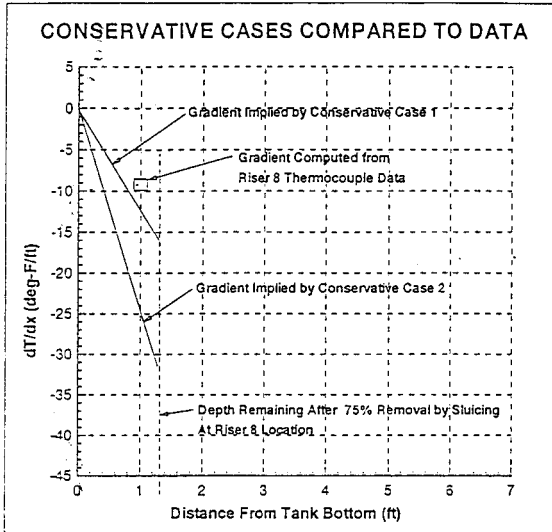


Figure 7. Conservative Cases Compared to Data.



**Westinghouse
Hanford Company**
**Internal
Memo**

From: Thermal Hydraulic Analysis
 Phone: 6-7143 H0-33
 Date: January 22, 1993
 Subject: TOTAL HEAT SOURCE IN TANK C-106

23210-TJB-93-048

To: J. P. Harris S4-55

cc: S. W. Claybrook H0-34
 C. Defigh-Price R2-31
 W. L. Knecht H0-34
 T. B. McCall H0-33
 O. S. Wang R2-32
 TJB File/LB

A comparison of transient calculated temperatures with thermocouple measurements during the ventilation outage in 1992 indicate that the total heat source in tank C-106 is 110,000 +/- 20,000 Btu/h. The attached figures show the calculated temperatures curves versus the measured thermocouple data (x's) for total heat sources of 130,000, 110,000, and 90,000 Btu/hr. The top figure is for level 1 of the thermocouple tree (4 in. from the bottom of the tank), the middle figure for level 2 (2 ft 4 in. from the bottom of the tank), and the bottom figure for level 3 (4 ft 4 in. from the bottom of the tank). Differences between measured and calculated temperatures at the other three levels of the thermocouple tree (6 ft 4 in.; 8 ft 4 in.; 10 ft 4 in.) are small.

A two-layer model was used for the calculated temperatures, since the temperature profiles for this model fit the measured profiles best. This model combines the bottom two sludge layers of the three-layer model previously developed. Some of the heat from the top layer has been included in the bottom layer due to settling of the radionuclide particles from the top layer to the bottom layer. The analyses for the complete history of the tank can incorporate this movement between layers by adjusting the heat source in each layer.

T. J. Bander

T. J. Bander
 Software Engineer

dsa

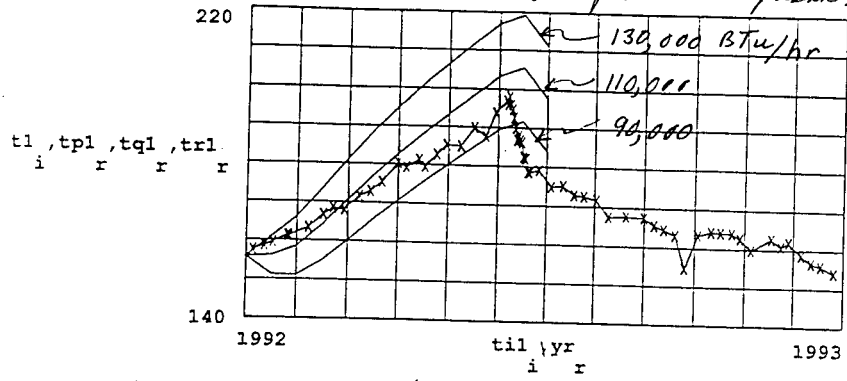
Attachment

CONCURRENCE:

T. B. McCall
 T. B. McCall
 Manager

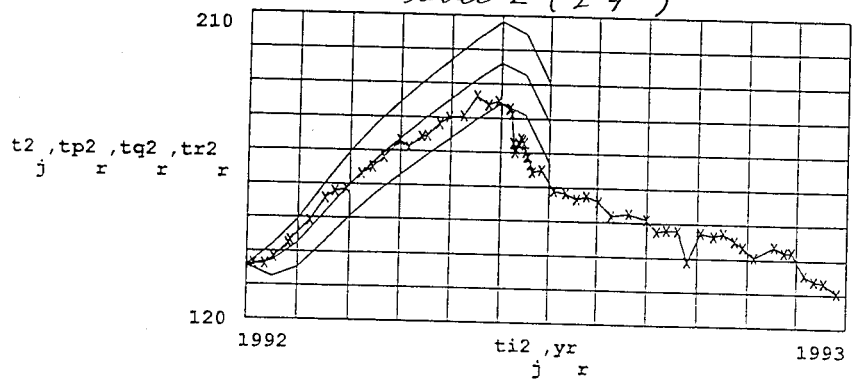
Date: 1/25/93

level 1 (4" from bottom of tank)



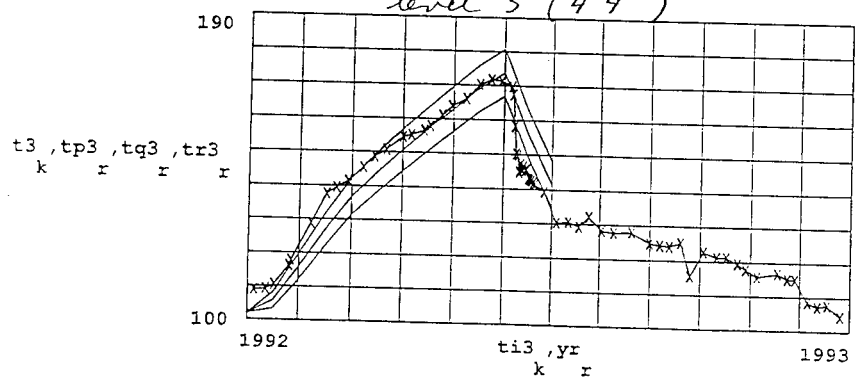
$t1, tp1, tq1, tr1$
 $i \quad r \quad r \quad r$

level 2 (2'4")



$t2, tp2, tq2, tr2$
 $j \quad r \quad r \quad r$

level 3 (4'4")



$t3, tp3, tq3, tr3$
 $k \quad r \quad r \quad r$

Westinghouse Hanford Company

Internal Memo

From: Process Engineering Analysis
 Phone: 376-0438 H0-34
 Date: July 12, 1996
 Subject: RECOMMENDATION FOR C-106 SLUICING

74A50-96-DMO-006

To: J. P. Harris, III S2-48

cc: T. J. Bander H0-34
 J. P. Bailey S2-40
 B. A. Crea H0-34
 J. C. Conner A2-25
 G. T. Dukelow S7-14
 J. P. Sloughter R2-54
 DMO File/LB

- References:
- (1) Bander, T. J., B. A. Crea, and D. M. Ogden, 1996, *Tank 241-C-106 Sluicing Evaluation*, WHC-SD-WM-ER-588, Rev. 1, Westinghouse Hanford Company, Richland, Washington
 - (2) Conner, J. C., 1996, *Safety Assessment for Tank 241-C-106 Waste Retrieval, Project W-320*, WHC-SD-WM-SAD-024, DRAFT, Westinghouse Hanford Company, Richland, Washington.
 - (3) Bander, T. J., 1995, *Tank 241-C-106 Process Test Report*, WHC-SD-WM-427, Rev. 0, Westinghouse Hanford Company, Richland, Washington.
 - (4) Ogden, D. M., and M. J. Thurgood, 1996, *Tank C-106 Contingency Chiller System Analysis*, WHC-SD-WM-ER-457, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Introduction

A thermal evaluation of the Project W-320 retrieval process was performed and documented in Reference 1. This study recommended incremental sluicing of tank 241-C-106. Incremental sluicing and hold periods of tank cooling will maintain the maximum waste temperatures below the local saturation (boiling) temperature during the sluicing operation as required by the project safety evaluation (Reference 2). The purpose of this letter is to provide a recommendation for the size of the incremental steps, the duration of the cooling periods, and necessary tank monitoring.

J. P. Harris, III
Page 2
July 12, 1996

74A50-96-DMO-006

Proposed Sluicing Strategy

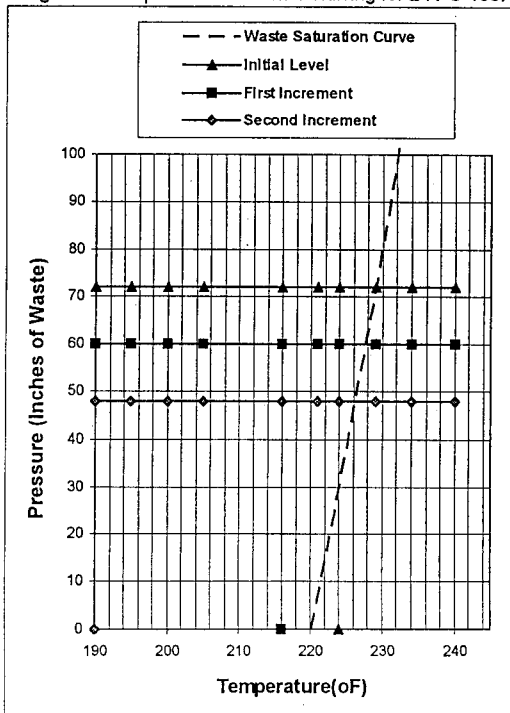
The proposed incremental sluicing eliminates the potential for steam bumps by maintaining a safe margin of subcooling (waste temperatures below the local saturation temperature) in the waste at all times. The sluicing is performed in incremental steps which are small so that the loss of pressure due to the waste removal will not reduce the saturation temperature to the local waste temperature, which is possible with the designed capacity of the sluicing system. The size of the incremental steps must account for uncertainties in parameters such as the maximum waste and saturation temperatures and level control during sluicing (uniform sluicing is desirable).

A meeting was conducted with Project W-320 personnel (John Harris, Construction Projects; John Bailey, Retrieval Engineering; John Conner, Projects SAR Engineering) to review the sluicing operation and level control issues. Historically, the liquid pool is removed prior to sluicing. This makes level control difficult and level monitoring possible by visual inspection only. In light of these difficulties, John Bailey recommended that the 241-C-106 sluicing be performed with a liquid pool covering the waste. Level would be maintained by controlling the slurry and sluicing jet pump rates. Sluicing (at a constant level) will continue until the particle loading of the transfer line reaches a minimum value, indicating that the waste some distance below the surface has been removed. Past sluicing has shown that sludge can be removed up to 1 foot below the liquid surface. The constant level sluicing will control the maximum sluicing depth and promote uniformity of the sluicing.

The proposed incremental sluicing (based upon the thermal evaluation of Reference 1 and discussions with Retrieval Engineering) is shown in Figure 1 and discussed in the following. The proposed liquid level for the first constant level sluicing is 72 inches (ENRAF measurement).

The C-106 1994 process test (Reference 3), which evaporated the liquid pool, showed that the

Figure 1. Proposed Incremental Sluicing for 241-C-106.



J. P. Harris, III
Page 3
July 12, 1996

74A50-96-DMO-006

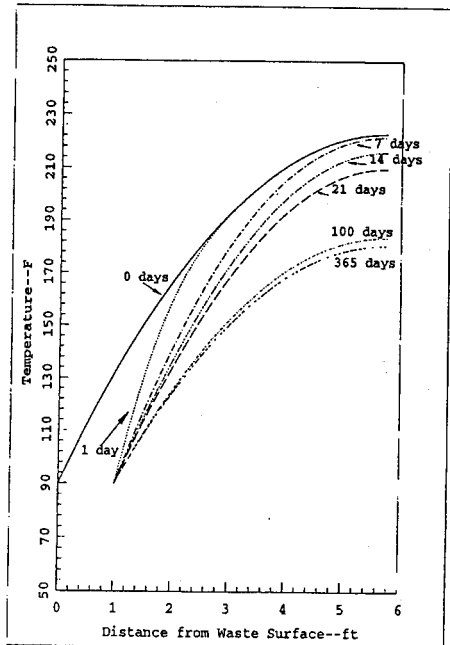
sludge level was near 69 inches. This would leave 2 to 3 inches covering the sludge. Figure 1 shows the saturation curve for C-106 waste, which includes vapor suppression. The saturation temperature for a waste level of 72 inches is about 229 °F. The maximum waste temperature following the operation of the tank chiller system (Reference 4) is predicted by analyses to be 224 °F (shown on the abscissa of the graph). This is approximately 5 °F subcooling, which should provide a margin of safety for uncertainties in temperatures and level.

The first incremental sluicing (prior to the draw down to the second incremental step) will remove sludge down to the 60-inch level while reducing the tank bottom pressure by only 5%. The liquid pool supports only a very small temperature gradient (due to convective flows). Thus, the conduction length for the sludge will be reduced by 1 foot with nearly the same pool boundary temperature and bottom pressure. A simple one-dimensional slab conduction model can be used to estimate the effect of the reduced conduction length (Reference 1).

Figure 2 shows the transient temperature response of a 5 foot slab of waste with a step change in the boundary temperature equivalent to the removal of 1 foot of sludge. After two weeks, the temperature at the 6 foot elevation has decreased from 224 °F to near 216 °F (shown on the abscissa of Figure 1). Thus, sluicing with a tank level at 72 inches followed by a cooling period of 14 days will reduce the maximum waste temperature to about 216 °F. If the liquid level is then drawn down to the 60-inch level to complete the first incremental sluicing, as seen in Figure 1, the saturation temperature will decrease to about 228 °F, but the waste temperature will have decreased to approximately 216 °F. This is over 10 °F of subcooling, which again will provide a margin of safety for uncertainties.

The second incremental sluicing should be performed at a constant liquid level of 60 inches, following the same procedure described above. The effect of the removal of an additional foot of sludge is shown in Figure 3, which shows the transient temperature history for a 4 foot slab of waste with a step boundary temperature change equivalent to the removal of 2 feet of sludge. After 14 days, the maximum waste temperature has decreased over 30 °F. The new

Figure 2. Slab Model (5 ft) Transient Temperatures.



J. P. Harris, III
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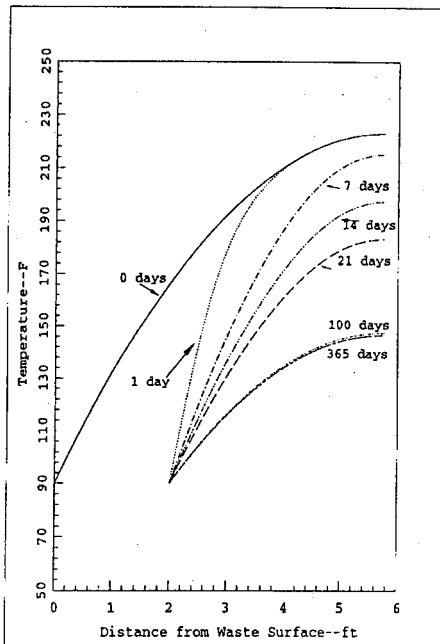
waste temperature would be approximately 185 °F to 190 °F (shown on the abscissa of Figure 1). The second incremental retrieval is completed by drawing the liquid level down to 48 inches. The new saturation temperature will be about 226 °F, while the maximum waste temperature will have decreased to 190 °F or less. This is over 30 °F subcooling. Furthermore, the maximum waste temperature is below the saturation temperature at atmospheric pressure, which completely eliminates any potential steam generation. Incremental retrieval to prevent steam bumps is not required after the second incremental step. However, flammable gas issues in the receiver tank (241-AY-102) may require the continuation of incremental retrieval.

Tank Monitoring

The proposed sluicing strategy requires the monitoring of tank liquid level during the retrieval process. The slurry submersible pump, which will be sluiced into the sludge, will include conductivity probes. The purpose of the probes is to measure the level in the well surrounding the pump. For the proposed constant liquid level sluicing, this instrument will measure the pool liquid level. This will provide a continuous level measurement. The ENRAF gauge will be withdrawn during the actual sluicing operation. However, it is recommended that the ENRAF gauge be periodically inserted to provide a second level measurement. It is recommended that the level be maintained as near constant as possible during sluicing. However, because of the subcooling margin discussed in the previous section, the level can deviate from the intended level by 6 inches and still provide adequate subcooling.

Other tank data, including temperature, should be continuously recorded, but will be most useful for a post sluicing evaluation. During the cooling period after each incremental sluicing, the temperature and ENRAF level data can be used to provide an assessment of the remaining tank heat load.

Figure 3. Slab Model (4 ft) Transient Temperatures.



J. P. Harris, III
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Summary of Recommendations

The following is a summary of the recommendations:

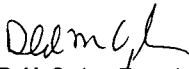
1. Tank 241-C-106 sluicing should be performed in 1 foot incremental steps with a 14 day cooling period. Two incremental steps are required to eliminate the steam bump potential.
2. The sluicing should be performed with a constant liquid pool, 72 inches for the first step, and 60 inches for the second.
3. Level should be continuously monitored by the submersible slurry pump conductivity probes with periodic verification by ENRAF measurements.



T. J. Bander, Principal Engineer
Process Engineering Analysis



B. A. Crea, Principal Engineer
Process Engineering Analysis



D. M. Ogden, Team Leader
Process Engineering Analysis

bab

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**Westinghouse
Hanford Company**
**Internal
Memo**

From: Waste Tanks Process Engineering 74A10-96-082
 Phone: 373-2461
 Date: June 10, 1996
 Subject: TANK 241-C-106 RETRIEVAL INDUCED FLAMMABLE GAS PLUME ANALYSIS

To: J. P. Harris S2-48

cc: D. G. Baide S2-48 P. A. Gauglitz P7-41
 J. W. Bailey S2-48 F. J. Heard H0-34
 W. B. Barton *WKB* R2-11 C. W. Stewart K7-15
 J. C. Conner A2-25 SDE File/LB

This memo discusses the issue of a potential gas plume resulting from disturbance and subsequent release of gas trapped in tank 241-C-106 waste by the mechanical agitation imparted by the sluice spray. At focus is the possibility of a localized gas release from the waste which could produce a gas plume in the tank headspace with a fuel concentration sufficient to support combustion. This memo documents the technical viewpoints of a number of experts on the behavior of gases in tank waste. The viewpoints regarding a sluicing induced gas plume at tank 241-C-106 are detailed in the supporting Attachments. The general findings are summarized below:

- There is not a significant amount of gas trapped in the tank.
- It is highly unlikely the gas is concentrated in any one location prone to immediate agitation and subsequent release by way of the sluice spray.
- Any waste, regardless of how rapidly or vigorously it is agitated, would release gas relatively slowly permitting significant dilution of the emitted gases by forced ventilation and other means of convection within the tank headspace.
- The gas would be diffused through a relatively large area of the waste surface, a fact which naturally tends to limit the resulting fuel concentration in any generated plume.

S. D. Estey

S. D. Estey
Senior Engineer

mjg

Attachments

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ATTACHMENT A

74A10-96-082

TANK 241-C-106 RETRIEVAL INDUCED FLAMMABLE GAS PLUME ANALYSIS

consisting of 6 pages

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Introduction

This analysis provides estimates of the magnitude of a plume formation in tank 241-C-106 which would be caused by the mechanical agitation of the tank waste due to the sluicing spray. The unique subjects to be addressed in this analysis are:

- 1) Distribution of Trapped Gas: What is the distribution of the flammable gas trapped within the tank waste?
- 2) Maximum Waste Volume Immediately Disturbed: What is the maximum amount of tank waste which could be immediately disturbed by the sluice spray?
- 3) Maximum Immediate Gas Release: Combining (1) and (2), what would be the maximum amount of gas which could be immediately released into the tank headspace?

The referenced memo analyzed the global situation where a maximum amount of trapped gas is immediately released and uniformly distributed within the tank headspace. With the assumptions and analyzed conditions, the limiting results were a total release of 100% of 531 ft³ of trapped gas, which is 97% hydrogen (Reference 1) equating to 546 SCF of hydrogen when corrected for estimated gas temperature and pressure (Attachment B). This would result in a fuel concentration of 17% LFL in the tank headspace. Thus, in this case the entire volume of gas trapped in tank 241-C-106 waste is insufficient to form a uniform flammable concentration throughout the tank headspace.

Distribution of Trapped Gas

The distribution of gas within the tank waste represents a range of possibilities. The gas could be trapped homogeneously throughout the waste or concentrated in discrete locations. The extreme situations would be that the waste volume which is being immediately sluiced contains either the entire volume of trapped gas, or none at all. A more reasonable scenario obviously is the one where the trapped gas is distributed uniformly throughout the waste volume. Varying degrees of these possibilities could be imagined, but uniform gas distribution would be viewed as more credible than the two extreme cases.

For the gas to be released from the waste, it must be located where the mechanical energy input of the sluice stream can dislodge it from the solids matrix. This leads to a conservative assumption that all the gas must be located in the soft sludge of the tank - the upper 3/4 of the waste volume - as it is believed that the bottom 1/4 of the waste volume - the hardpan - has mechanical strength higher than that which can be overcome by the sluice stream. This assumption leads to a waste volume of 150 kgal in which the gas can be distributed.

Two methods are used to estimate the volume of trapped gas for this analysis:

Case 1 - The values from Reference 1 and Attachment B are used, yielding 531 ft³ of compressed gas with 97% hydrogen which equates to in 546 SCF of hydrogen.

Case 2 - A conservative assumption that the tank waste has a 5% void volume containing gas. Level rise/evaporation methods for estimating tank waste gas content, which were used in Reference 1, may be considered unreliable. Therefore, a conservative approach, when no gas volume estimate is available, is to assume the waste has a 5% void volume. The latest estimates of waste gas generation show that the hydrogen content in the waste gases produced can be conservatively stated as 50% by volume (Reference 2). With such an estimate, the maximum volume of gas that can be released is $150,000 \times 0.05/7.48 \times 0.5 = 500 \text{ ft}^3$ hydrogen, which can be equated to $500 \times 1.22 \times 0.87$ or 530 SCF hydrogen in accordance with the assumptions of Attachment B.

Maximum Waste Volume Immediately Disturbed

Two estimates have been provided by Project W-320 to indicate the maximum volume of waste which could be disturbed by the sluicer spray at any one time. The calculation of these estimates are shown in Attachment C. One estimate is that approximately 3,500 gallons, or about 2.3% of the total volume of waste capable of trapping gas within the tank, can be immediately disturbed. The second estimate yielded a volumetric disturbance rate of 1,800 gallons per second, which could be maintained for a maximum of 15 seconds at the maximum sluicer sweep rate of 6 degrees arc per second. These estimates yield a number of possibilities for the gas "source term". These include 3,500 gallons of waste disturbed instantaneously, 1,800 gallons of waste disturbed in one second, and 27,000 gallons of waste disturbed in 15 seconds. This analysis will choose two of these possibilities:

Case A - 3,500 gallons of waste disturbed instantaneously

Case B - 27,000 gallons disturbed in 15 seconds

Any larger waste disturbances would require longer agitation periods, and thus the gas released would more likely be dissipated by headspace convection to a lower fuel concentration.

Resulting Gas Release

From the preceding, the smallest volume of gas that could be immediately released is, obviously, 0 SCF. The largest would be the entire volume of hydrogen, 546 SCF for Case 1 and 530 SCF for Case 2. A more reasonable estimate of the volume of gas released would be that originating from the volume of waste which is disturbed. This would be $(3,500/150,000)$ or 2.3% of the total hydrogen volume for Case A or $(27,000/150,000)$ or 18% for Case B.

Hypothesized Hydrogen Release Volumes (SCF)

<u>Waste Disturbance Estimate</u>	<u>Gas Inventory Estimate</u>	
	Case 1	Case 2
Limiting (all gas released)	546	530
Case A (3,500 gal disturbed)	13	12
Case B (27,000 gal disturbed)	98	95

Additional Considerations

The problem with the limiting scenario, the instantaneous release of the total volume of trapped hydrogen, is that there is no known mechanism which explains how it could occur. For example, it is estimated that if tank waste has enough mechanical strength to retain a 1 m^3 (55 ft^3) gas bubble, it will have a yield strength of 6700 Pa. If the yield strength is reduced to 67 Pa, the maximum bubble size becomes 1 cm^3 ($5.5 \times 10^{-5} \text{ ft}^3$) (References 3 & 4). The fact that the high heat sludge in the tank is easily sampled via the bottle on a string method indicates that the yield strength of this sludge can be no more than a few hundred Pa. Correspondingly, the largest bubble size to be expected is no more than a few to a few tens of cm^3 , an indication that any trapped gas must be well distributed throughout the waste. Therefore, it appears the probability that the gas is distributed in such a way as to be immediately released upon agitation by sluicing is extremely unlikely, thus preventing the limiting release from becoming the best estimated release.

A temporal mitigating factor is thought to apply to this situation. This is the actual rate of gas release from the agitated waste. As has been demonstrated in testing with the mixer pump in tank 241-SY-101, the gas released from agitated waste is not instantaneous (References 5 & 6). Although the situations are different in that gas released from agitated waste in tank 241-C-106 does not have to diffuse and/or buoy itself through as great a distance as in tank 241-SY-101, some delay between waste disturbance and the majority of gas release is expected. This provides the expectation that a gas release on the order of minutes would be much more likely than a release on the order of seconds following an immediate disturbance of the waste.

The apparent lag time between waste agitation and complete gas release from the waste seems to suggest that over short time periods (e.g., 15 seconds or less), it is the total volume of waste disturbed, and not the rate at which it is disturbed, that is important in determining the volume of a gas release. However, regardless of the volume of hydrogen released, any delay between waste agitation and complete gas emission allows for dilution of the released

hydrogen through convective action in the tank headspace, making it less likely that a flammable plume could develop. This argument is assumed here to indicate that the hydrogen release determined from Case B forms a better "best estimated worst release" than that determined from Case A.

In addition, spatial factors should constrain the maximum achievable plume fuel concentration. The gas produced from the disturbance of tank waste will be emitted over a significant area of the waste surface. This is particularly true for Case B, where the waste disturbance is over a path six feet wide and through an arc length of about 70 feet with radius 45 feet, yielding a surface area of about 420 square feet. Even a waste disturbance over the smallest surface area, indicated by Case A as a circle six feet in diameter, represents an area of about 30 square feet. Compared to a point release, the geometry of sluicer operation suggests a small hydrogen flux passing through the waste surface, further limiting the achievable fuel concentration at any point in the tank headspace.

Other Gas Release Concerns

Concerns over the release of gasses dissolved in the tank waste can be postulated. The only gas of significance in this category is ammonia. Agitation of the tank waste will alter the pressure on and temperature of the wastes containing the ammonia and will result in a new partitioning of the ammonia between its gaseous and condensed phases - possibly increasing the ammonia concentration of the headspace. However, even this concern has several mitigating features associated with it. First, the amount of ammonia will not be sufficient to create, or significantly contribute to, a flammable condition in the tank headspace. Second, the act of agitating the sludge with the sluice spray will most likely cool the waste, increasing the solubility of any dissolved gases, thus lowering the partial pressure of the ammonia. Finally, the rate of release of the soluble gas depends on the surface area for mass transfer, which itself is a function of the amount of waste agitation. This indicates that the rate of release of dissolved ammonia can be controlled by the rate of sluicing in the tank, and will decay to its steady state equilibrium value when sluicing is stopped.

Conclusions

The hydrogen volumes which could be released due to sluicing agitation appear to be insignificant for tank 241-C-106, and the physical behavior of the released gases further diminishes the probability of forming a flammable plume in the tank headspace. The best estimates from this analysis are that:

1. If the total volume of gas trapped in the tank waste is released, the maximum amount of hydrogen gas emitted should not exceed 550 SCF. However, because homogeneous distribution of trapped gas is suspected, the total amount of hydrogen released over a short time period due to sluicing agitation is unlikely to exceed 100 SCF.
2. Even if the hydrogen is released over a short time period, the actual rate of gas release from the waste would tend to lower the plume fuel concentration when compared to an instantaneous gas release.
3. Regardless of the amount of hydrogen released, the large waste surface area through which the hydrogen will be diffused would produce a plume with significantly lower fuel concentration compared to that produced via emission from a point source.

References:

- (1) Internal Memo 74A10-96-027, J. D. Hopkins to J. C. Conner, *FLAMMABLE GAS EVALUATION OF TANK 241-C-106*, February 26, 1996.
- (2) Antoniak, Z. I., and K. P. Recknagle, May 31, 1996, *Modeling Hydrogen Plume Concentrations in Single and Double Shell Tank Domes*, TWSFG96.12, Pacific Northwest National Laboratory.
- (3) Alleman, R. T., October 1995, *A Discussion of Some Mechanisms for Sudden Gas Release from Single Shell Waste Tanks at Hanford*, PNL-WTS-101095, Pacific Northwest Laboratory.
- (4) *Proceedings of 29th European Study Group with Industry*, March 18-22, 1996, Mathematical Institute, Oxford University, U.K.
- (5) Alleman, R. T., Z. I. Antoniak, W. D. Chvala, L. E. Efferding, J. G. Fadeff, J. R. Friley, W. B. Gregory, J. D. Hudson, J. J. Irwin, N. W. Kirch, T. E. Michener, F. E. Panisko, C. W. Stewart, B. M. Wise, 1994, *Mitigation of Tank 241-SY-101 by Pump Mixing: Results of Testing Phases A and B*, PNL-9423, Pacific Northwest Laboratory
- (6) Stewart, C. W., J. D. Hudson, J. R. Friley, F. E. Panisko, Z. I. Antoniak, J. J. Irwin, J. G. Fadeff, L. E. Efferding, T. E. Michener, N. W. Kirch, D. A. Reynolds, 1994, *Mitigation of Tank 241-SY-101 by Pump Mixing: Results of Full Scale Testing*, PNL-9959, Pacific Northwest Laboratory

ATTACHMENT B

74A10-96-082

TANK 241-C-106 RETRIEVAL INDUCED FLAMMABLE GAS PLUME ANALYSIS

consisting of 2 pages

Barometric Analysis - Tank 241-C-106

Tank No.

enter	enter	C-106
-------	-------	-------

Calculation date:

Total Waste, gal. - from Hanlon's Summary Rpt	enter	gal	enter	gal	229,000
Total Waste, ft3. - converted from above		ft3		ft3	30,613
Total solids (sludge + saltcake), incl. gas - from Hanlon's Summary Report	enter	gal	enter	gal	197,000
Total Solids, ft3. - converted from above		ft3		ft3	26,335
Current surface level ht. in inches.	enter	in.	enter	in.	79.00
Supernat vol., gal - from Hanlon's Summary Report	enter	gal	enter	gal	32,000
Supernat density, g/mL	enter	g/mL	enter	g/mL	1.10
Supernat depth = supernat vol (gal)/2754 gal/in		in.		in.	11.62
Solids density, g/mL	enter	g/mL	enter	g/mL	1.43
WET Solids (below water table) & solids thickness - est. fm photo & total solids		in.		in.	67.36
Average gas location above tank bottom		in.		in.	15.2
Solids thickness over center of trapped gas (from top of solids)		in.		in.	52.21
Average temp, °F:	enter	°F	enter	°F	155
Average tank temp, °C:		°C		°C	
Average tank temp, K:		K		K	341.5
Tank TOTAL VOL, ft3 - info in following lines	enter	ft3	enter	ft3	114,400
SST, Dish, 530 kgal - B, BX, C, T, U		ft3		ft3	
SST, Dish, 758 kgal - BY, S, TX, TY		ft3		ft3	
SST, Dish, 1000 kgal - SX		ft3		ft3	
SST, FLAT, 1000 kgal - A & AX		ft3		ft3	
DST, FLAT: AN, AP, AW, AY, AZ, SY		ft3		ft3	
Waste Volume (cu ft) with trapped gas, calculated from current surface level		ft3		ft3	30,759
Tx Hd Space (b4 release) =Dome vol-waste volume (w trappd gas)		ft3		ft3	83,641

0.0062966307

CALCULATION USING PAUL WHITNEY'S SLOPE

Patm, in. Hg	enter here	in. Hg	enter here	in. Hg	29.5
Patm		psia		psia	14.489
Pliq					
liq density		g/mL		g/mL	1.10
liq height		in		in	11.62
Pliq		psi		psi	0.462
Psolids					
solids density		g/mL		g/mL	1.43
solids height over center of trapped gas		in		in	52.21
Psl		psi		psi	2.697
Psurface tension					0.050
PTOTAL		psia		psia	17.698
Percentile level	enter here	75%	enter here	75%	75%
Paul Whitney's SLOPE = Δ surface level / Δ in. Hg		in/in Hg		in/in Hg	-0.040
Porosity: 1.0 for normal eval, actual porosity for ILL data					1
V(ft3, compressed) = Porosity at liq sfc - A(sq ft) x Total P(in. Hg) x slope(in./in Hg)		ft3	Hg)	ft3	531
V(scf) = Porosity x V(compressed) * T Correctn * P correctn					

Barometric Analysis - Tank 241-C-106

Tank No.

enter	enter	C-106
-------	-------	-------

CALCULATION OF %LFL

Volume of Entrapped Gas Released to Dome Space

Relevant data copied from data section

Compressed Vol of entrapped gas	ft ³	ft ³	531
Supernate density	g/mL	g/mL	1.10
Supernate depth	in.	in.	11.62
Solids density	g/mL	g/mL	1.43
Solids thickness to center of trapped gas	in.	in.	52.21
Waste temp at gas depth (F)	°F	°F	155.0
Waste temp at gas depth (K)	K	K	341.48
%H2 in entrapped gas	enter here	enter here	97%
Fraction of entrapped gas released (%)	enter here	0.25 enter here	100%

Calculations

Supernate head = supernate density x supernat depth (psi)	psi	psi	0.462
Solids head = solids density x solids depth (psi)	psi	psi	2.70
Pressure in dome, in psia (If cal'g H2 in scf, use 14.69)	enter here psia	enter here psia	14.69
Total head (psi) = Press in dome + sup. head + solids head	psi	psi	17.85
Pressure adjustment to scf = total head/TANK PRESSURE in psia			1.22
Temperature adjustment to scf = 298.15K/Waste temp at gas depth (K)			0.87
Comprsd vol x P adjstmt x T adjstmt x fractn of gas releasd=	scf	scf	563
Vol of entrapped gas released to dome space (scf)	scf	scf	563

Volume of H2 Released to Dome Space

Comprsd vol x P adjstmt x T adjstmt x fractn of gas releasd=	scf	scf	546
H2 Released to Dome Space (scf)	scf	scf	546

Vol. of Head Space

Vol of head space before burp	ft ³	ft ³	83,641
Compressed vol X fraction of entrapped gas released = scf level drop			
head space vol. increase caused by scf level drop	ft ³	ft ³	531
Vol of head space after burp	ft ³	ft ³	84,172

H2 % In Head Space

Vol. of H2 in Head Space/Vol of head space after burp			0.649%
---	--	--	--------

NH3 % In head space =

Assume NH3 vol = this fraction of entrapped gas released (max = 0.259)	enter here	enter here	0.220
NH3 vol in head space = NH3 fraction X vol of entrapped gas released	ft ³	ft ³	124
NH3 % In head space =			0.147%

TEST VS. CRITERIA (% of LFL)

% LFL = ((H2)/0.04) + ((NH3)/0.15) = 17.20%

REALITY CHECK: void space of total waste (except for pockets, voids > 20% unlikely) 1.73%

REALITY CHECK: void space of solids (except for pockets, voids > 20% unlikely) 2.01%

RESULTS: OK

Tank No.

enter	in/in Hg	enter	in/in Hg	C-106
enter	in/in Hg	enter	in/in Hg	-0.04

Slope at 95% confidence

Slope at 75% confidence

ATTACHMENT C

74A10-96-082

TANK 241-C-106 RETRIEVAL INDUCED FLAMMABLE GAS PLUME ANALYSIS

consisting of 4 pages

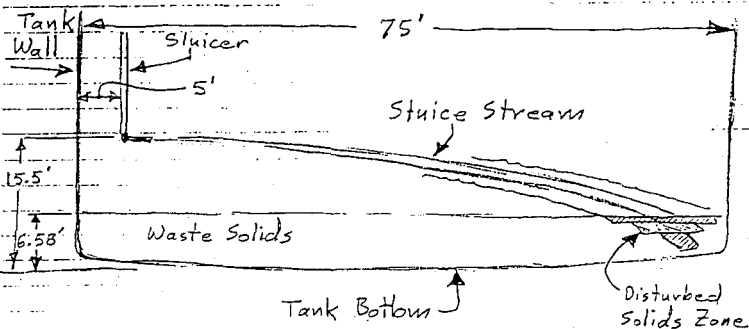
DESIGN ANALYSIS

Subject Tank 241-C-106 Sluicing - Disturbed Solids Volume Estimate	Date 5/30/86	By John W. Bailey
Location	Checked	By
	Revised	By

Purpose: This calculation estimates the volume of solids in tank 241-C-106 which could be disturbed by the sluicing stream on an instantaneous basis.

Background: - The preparing engineer conducted sluice nozzle testing in 1976 to refine the sluicer aiming diagram used in operating procedures at that time. The effectiveness of the sluice stream to remove sand from a 4' x 8' test pan was also evaluated. The results of this undocumented testing is used as the basis for this estimate. NOTE: The sluice stream at a range from the sluice nozzle of approximately 45' remove the majority of a 6" layer of sand from the test pan in less than 5 seconds.

Sluicer / Sluice Stream Configuration -

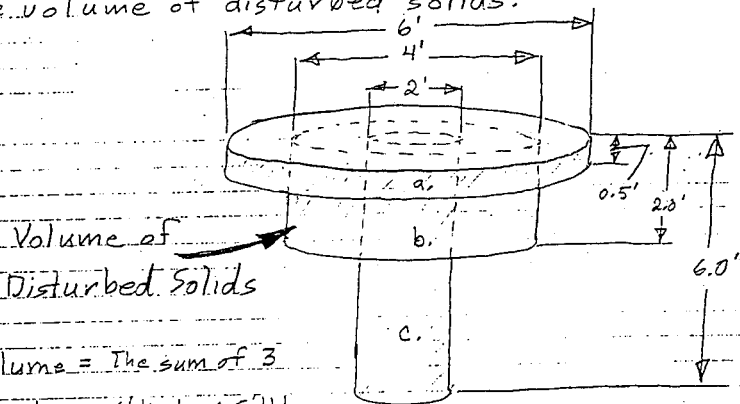


(Continued)

DESIGN ANALYSIS

Subject Tank 241-C-106 Sluicing - Date 5/30/96 By J.W. Bailey
Disturbed Solids Volume Estimate Checked By
Location Revised By

Assumption - The sluice stream is most effective at disturbing sludge solids in the center of the stream and becomes marked less effective as you move away from the center of the stream. For purposes of this estimate the below model is used to estimate the volume of disturbed solids.



Volume = The sum of 3 cylinders
6' dia by 0.5' thk
4' " " 1.5' "
2' " " 1.5' "

$$\text{Formula } \sum_{i=1}^n \pi r^2 h = \pi 3^2 (0.5) + \pi 2^2 (1.5) + \pi 1^2 (4)$$

$$= \pi (4.5 + 6 + 4)$$

$$= 14.5 \pi = 45.6 \text{ ft}^3$$

Converting to gallons $45.6 \text{ ft}^3 \times \frac{7.5 \text{ gal}}{\text{ft}^3} \approx 342 \text{ gal.}$

Rounding up to 350 gal.

To assure conservatism and to address both the potential for
(continued)

DESIGN ANALYSIS

Subject Tank 241-C-106 Sluicing -	Date 5/30/96	By John W. Bailey
Disturbed Solids Volume Estimate	Checked	By
Location	Revised	By

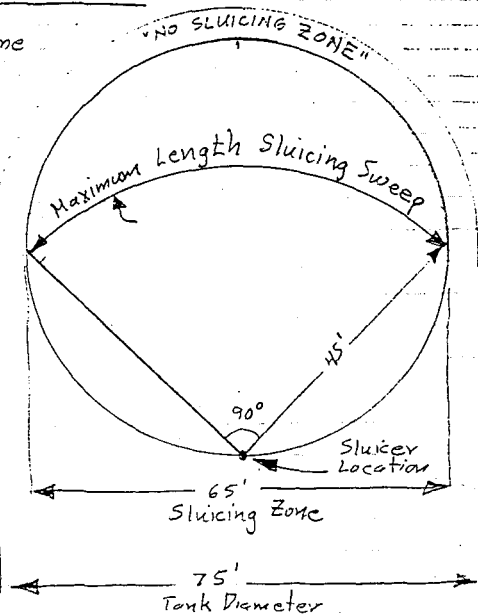
the disturbed solids to effect the immediately adjacent undisturbed solids causing them to release gas and potential effects of the moving sluice stream to enlarge the disturbed zone, the above estimate is increased by an order of magnitude to 3,500 gal or roughly 2% of the current sludge volume in tank 241-C-106.

ALTERNATE CALCULATION APPROACH:

A solids disturbed per unit time calculation was performed.

It assumed the same disturbed solids volume was swept across the widest part of the tank with the sluicer drive set to maximum travel rate (6°/sec).

The figure to the right shows this path. At 6°/sec this path would be swept in 15 seconds. The volume



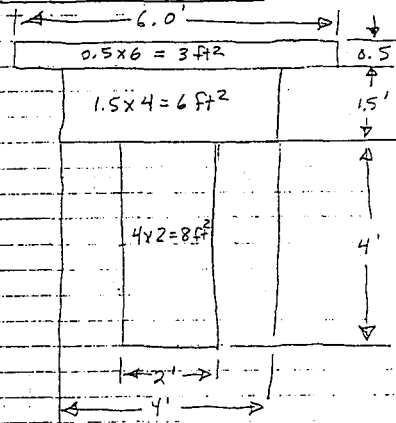
DESIGN ANALYSIS

Subject <u>Tank 241-C-106 Slicing</u>	Date <u>6/4/96</u>	By <u>John W. Bailey</u>
<u>Disturbed Solids Volume Estimate</u>	Checked	By
Location	Revised	By

of solids disturbed in this 15 seconds would be approximate each to the length of the path times the cross sectional area of the Disturbed Solids Volume figure (Ref Pg#2).

$$\text{Length of Path} = \frac{\pi \cdot (\text{Diameter of sweep circle})}{4 \text{ [Only 1/4 circle is swept]}} = \frac{\pi \cdot 2(45' \text{ radius})}{4} \approx \boxed{70.7'}$$

Cross Sectional Area



Summing the 3 areas

$$3 \text{ ft}^2 + 6 \text{ ft}^2 + 8 \text{ ft}^2 = \boxed{17 \text{ ft}^2}$$

Disturbed Volume

$$70.7' \times 17 \text{ ft}^2 \approx 1202 \text{ ft}^3$$

Converting to gallons

$$1202 \text{ ft}^3 \times \frac{7.5 \text{ gal}}{1 \text{ ft}^3} = 9,014 \text{ gal}$$

SAY 9,000 gal

Unit Time Disturbed Volume

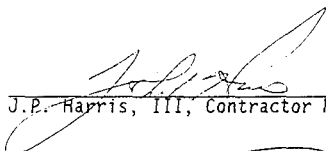
$$\frac{9000 \text{ gal}}{15 \text{ seconds}} = \boxed{600 \text{ gal/sec.}}$$

To ensure conservatism and address the potential for the disturbed solids to effect the immediately adjacent solids causing them to release trapped gases the above figure is multiplied by 3 giving 1,800 gal/sec

Meeting Minutes
Discussion of Interim Status Requirements
Pump and Sluice Pits at Tank Farm 241-C
Sluicing of Tank 241-C-106

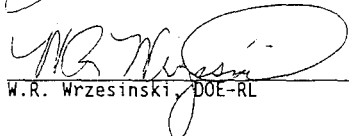
VIDEOCONFERENCE MINUTES
June 27, 1995

The undersigned indicate by their signatures that these meeting minutes reflect the actual occurrences of the above dated Meeting.



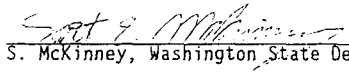
J.P. Harris, III, Contractor Representative, WHC

Date: 8-7-95



W.R. Wrzesinski, DOE-RL

Date: 8/7/95



S. McKinney, Washington State Department of Ecology

Date: 8/2/95

Purpose: Discuss coating of the pump and sluice pits at Tank Farm 241-C and the associated ventilation duct secondary containment.

MEETING MINUTES

Subject: Project W-320, Tank 241-C-106 Sluicing/Pit Compliance and Ventilation Duct Containment Issues

TO: Scott McKinney BUILDING Ecology/Lacey

FROM: John P. Harris III WHC, SST Retrieval Projects

Department-Operation- Component	Area	Date of Meeting	Number Attending
Tank Farm Transition Projects	200E	June 27, 1995	

This meeting was called by WHC to discuss two issues, the first of which involved the coating of the pump and sluice pits at Tank Farm 241-C. The second issue involved the ventilation duct containment.

Issue #1

The preparation for the sluicing retrieval does not include plans to apply an impervious coating to the internal concrete surfaces of the pits due to the radiological activity levels within the pits. These activity levels require all upgrade work to be done remotely with the associated increased costs and time required before the sluicing operation may begin.

The pump and sluice pits are to be used during the sluicing of Tank 241-C-106 (C-106) to resolve the high-heat safety issue within the tank in accordance with Tri-Party Agreement Milestone M-45-03A (the third pit on the tank, the heel pit, is not currently within the project scope to be used during the sluicing retrieval). The sluicing of Tank C-106 is the first phase of, and supports the eventual closure of this single shell tank. Therefore, it was felt that any upgrades to this ancillary equipment on the tank, as required by 40 CFR 265.193(f), would not provide a benefit commensurate with the environmental and health risks, based on the radioactive dose investment requirements by the involved workers; nor would it be cost effective, based on the cost and schedule impacts to the successful completion of the safety issue resolution. The waste retrieval sluicing system (WRSS) is being designed and constructed for a useful lifetime of 2 years, of which the sluicing retrieval is expected to take a period of approximately 3-6 months of actual pumping operation. Current requirements call for a scheduled commencement of retrieval in October, 1996 (DOE Secretarial Safety Initiative); one year ahead of the Tri-Party Agreement Milestone requirement of October, 1997.

During the sluicing activity; two at-grade, bermed, double-encased transfer lines are to be installed between C-106 and Tank 241-AY-102 (AY-102). These lines are to be used simultaneously to set up a flow loop between the tanks. The sluice line will transfer 350 gpm of clarified supernate from AY-102 to a sluice nozzle in C-106. The mobilized slurry will then be pumped back to AY-102 via the slurry line, again at roughly 350 gpm, where the solids will

settle, and the flow loop will continue. The slurry line will enter the C-106 pump pit, where it will be jumpered to the slurry pump discharge riser. The sluice line will be routed to the sluice pit directly, bypassing the pump pit. Because of this piping arrangement, a possible accident scenario for the pump and sluice pits would involve a maximum leakage rate of 350 gpm, which has been provided for in the design via slotted extensions to the pump riser and the sluicer riser to be able to drain the worst case leakage flow to the tank without accumulating liquid in the pits. In addition, the pump pit also has a floor drain with leak detection to accommodate small volume leaks (the sluice pit floor drain is currently plugged and will probably not be able to be cleared). Should there be a recurrence of past difficulties with pluggage of the floor drain in the pump pit (the floor drain design involves the use of an annular space on the order of 1/8" around a 12" riser in the pit, so that debris and sand have plugged these in the past), sump pumps will be installed in the pits to remove the approximately one inch depth between the bottom of the high-volume drain slots and the pit floor.

Visual inspections during preparatory work in 1994 to clean the pits of debris and lower the radiation fields revealed some standing water in the pits from precipitation intrusion (the floor drains in both pits were then plugged). Videotapes of this standing water in A-pit (Pump pit) were obtained on October 12, 13, and 14, 1994 and again on November 15, 16, and 17, 1994. The C-pit (sluice pit) was videotaped on January 16, 17, and 18, 1995. Examination of these tapes, combined with field observations around these dates indicated no visible drop in the liquid levels in the pits. Based on this evidence, it was determined by WHC that the pits could contain any potential leakage experienced (until the sump pumps could remove any residual liquid below the bottom of the high-volume drain slots) with minimal risk of additional environmental insult to the soil column in the vicinity of the tank.

The pits are of concrete construction with a sloping bottom. The pump pit has dimensions of 11 feet by 14.5 feet by 6.4 feet depth for a volume of 1021 cubic feet. The sluice pit has dimensions of 8.5 feet by 9 feet by 7.67 feet depth for a volume of 587 cubic feet. The maximum drainback possible from the transfer lines to C-106 pits with the pumps stopped is approximately 1000 gallons per line. Given these considerations, any threat to the environment from a pipe failure would be minimal.

Originally, the scope of the project included a coating of the pits. These pits are extremely contaminated, and will be in use only during the tank sluicing. The ALARA concerns involved in coating these pits far exceed any potential benefits. Workers are exposed to general radiation fields around the pit of approximately 70 mrem/hr, though current decontamination efforts are continuing to attempt to lower this by an order of magnitude. In order for the pit coating to be done (assuming no great success in reducing the radiation field), workers would be exposed to fields as high as several rem (directly in the "shine" of the radiation fields coming out of the pits). These factors greatly increase the costs and time that would be involved in coating the pit, since this work would involve several employee-months of time to complete. Currently, there is also a move to bring the project costs within the available budget (recent events such as the temperature anomalies experienced in the tank in 1994 have caused delays in the project's schedule with resultant schedule compressions and cost increases). This cost reduction

effort has driven some project scope reductions (as outlined in the Unit Manager Meeting of June, 1995). Coating of the C-106 pits was dropped based on the aforementioned cost/risk/benefit evaluation.

Given that the design of the pits, combined with operational commitments on the operation of the pit sump pumps, will prevent the accumulation of liquids within the pit, as well as the ALARA and cost concerns discussed above, it was agreed by the signatories of these minutes that this project will proceed without requiring coating of the C-106 pits.

Issue #2

The second issue that needed to be discussed was the acceptability of the proposed method of providing secondary containment for a valve in the proposed tank ventilation system recirculation duct. This issue arose as a result of analyses relating to tank headspace radioactive and non-radioactive source terms. The design, as originally provided to Ecology, included the use of a heater in the recirculation line (downstream of a condenser and a de-mister) which would ensure that the air flow would have a moisture content well below the saturation point. The aforementioned analyses indicated that a possibility existed that the use of the heater could accumulate dry particulate in the headspace of the tank beyond that reported as a source term for the Air Permit Notice of Construction. So, WHC proposed to leave the heater off during operation, at which point it was realized that this would result in cold, saturated air going through the vent duct back to the tank. Though this was not a process problem, it would require a double containment for the non-sealless valve in the duct, since some condensation could occur in the duct (though the duct would remain at several inches negative pressure during operation so that any leakage occurring should be inward).

40 CFR 265.193(f) requires that ancillary equipment for a tank system must have double-containment unless it contains sealless valves, that are inspected on a daily basis. The secondary containment planned for the applicable sections of the vent line is a flexible membrane, which has been standard practice for similar systems at the Hanford Site. The vent line will be visually inspected for leaks on a daily basis. Any accumulated liquid in the secondary containment of the vent line will be removed in as timely a manner as is possible to prevent harm to human health or the environment, though Ecology stressed at the meeting that it was not the intent that operators should immediately remove any liquid discovered in the container, since condensation from the air in the secondary container bag was a likely occurrence, especially during warm weather. Rather, it was expected by Ecology that operators would exercise sound judgement in observing the condition of the container to determine whether ambient conditions and trends supported an apparent leak, or a sweating of the duct. To try to minimize the occurrence of sweating of the duct, the signatories agreed to the insulating of the ventilation recirculation duct from the process building to the tank, combined with the "bagging" of the valve. It was agreed by the signatories of these minutes that this method of providing secondary containment for the associated vent lines meets the intent of the interim status standards contained in the WAC 173-303-400 and 40 CFR Part 265.193.

As an additional discussion area, WHC brought up the point that, during the investigation of the physical configuration of the recirculation line valve in

the design drawings in preparation for the meeting, it was realized that there were several other singly contained ventilation lines coming out of the process building with non-sealless valves. All of these lines ended with a blank flange (i.e., a bolted cover which would be removed immediately before use). These lines included maintenance lines for flushing of the condenser, monitoring lines for determining decontamination factors for control equipment such as the High Efficiency Mist Eliminator and the High Efficiency Metal Filter, and a line for connection of a portable exhaustor (should a failure of the ventilation system occur). The signatories of these minutes agreed that, because these lines were sloped inward toward the process building such that no condensation could pool in the lines, they did not require secondary containment.

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**Westinghouse
Hanford Company**

**Internal
Memo**

From: Liquid Effluents Services
 Phone: 373-0087 H6-06
 Date: August 1, 1996
 Subject: CONSISTENCY REVIEW OF WHC-SD-WM-SAD-024, REV 0 "SAFETY ASSESSMENT FOR TANK 241-C-106 WASTE RETRIEVAL PROJECT W-320"

To: J. P. Harris, III S2-48
 cc: W. Abdul, RL S7-53
 D. G. Baide S2-48
 J. C. Conner A2-25
 B. L. Nicoll, RL S7-53

Per your request, I have completed a consistency review of the subject safety assessment (SAD) with respect to the conclusions presented in the following documents:

- (1) WHC-SD-WM-ER-588, Rev 0, "Tank 21-C-106 Sluicing Evaluation" and the associated Westinghouse Hanford Company Internal Memo 74A50-96-DMO-006, "Recommendation for C-106 Sluicing."
- (2) WHC-SD-W320-TI-007, Rev 0, "Flammable Gas and Steam Controls for WRSS Operation, Project W-320."
- (3) WHC-SD-WM-ER-594, Rev 0, "Evaluation of Recommendation for Addition of Tanks to the Flammable Gas Watch List."

The consistency of the SAD to the above document conclusions was assessed by first reviewing each document separately and listing the important conclusions presented in each document. The product of this initial review is provided in Attachments 1 through 3, where the important conclusions are listed for each document. Next a page-by-page review of the SAD was undertaken during which the SAD content was compared to the combined conclusions contained in Attachments 1 through 3. Where it was felt that an inconsistency may exist between the May 1996 version of the SAD and the above document conclusions, this was noted along with the exact location in the SAD and suggested modifications to eliminate the inconsistency. The product of the page-by-page SAD review is as follows:

1. Section 2.1.6.2, p. 2-12, first paragraph: Suggest qualifying the May 1996 version discussion on "...continuous, closed-loop sluicing process" to include the incremental waste retrieval approach followed with monitoring or hold periods. An appropriate SAD section reference where this approach is discussed in detail should be provided.

J. P. Harris, III
August 1, 1996
Page 2

2. P. 2-46, last paragraph: Suggest that the May 1996 version discussion of "...series of sluice channels...to channel the slurry flow directly to the slurry pump" be revised since this may not be compatible with the concept of incremental retrieval of waste by controlled level sluicing (i.e., constant liquid level covering the sludge layer).
3. P. 2-47, fourth full paragraph and subsection "Sluicing Temporary Shutdown Operations": Suggest that the May 1996 version discussion of alternative approaches for precluding local superheated waste locations "...by maintaining a wet waste surface by either submersion or through frequent...hosing down of the waste surface..." and two bullets in subsequent subsection be revised to indicate that sluicing will be performed with a constant liquid pool level in tank C-106 with no waste exposed (except possibly at the tank wall).
4. P. 4-34, first paragraph: Suggest that the May 1966 version discussion of sluicing-induced steam flash in tank C-106 be modified to include the concept that the waste sludge will always remain covered with supernatant and that a constant pool liquid level will be maintained. Also, the "...1 to 2 week hold period..." should be changed to a minimum hold period of 2 weeks.
5. Table 5-9, P. 5-18, "Mitigation" column under "Temperature anomaly and steam release" and Section 5.6.1.4, P. 5-30: Suggest that the May 1996 version be modified to include a discussion of the mitigation that will be provided by the process controls and procedures associated with the incremental waste retrieval operation followed by cooling hold periods.
6. Table 5-9, P. 5-18, "Mitigation" column under "Tank bump" event: Suggest adding "monitoring/hold periods" to the controls that will mitigate this event.

During the page-by-page SAD review, a number of typographical/editorial errors were noted. These will be forwarded for your review and consideration under separate cover.



D.I. Herborn, Fellow Engineer

ajb

Attachments (3)

Attachment 1

IMPORTANT CONCLUSIONS

WHC-SD-WM-ER-588, Rev 0, "Tank 241-C-106 Sluicing Evaluation"
and
WHC Internal Memo, "Recommendation for C-106 Sluicing"

1. Purpose of evaluation to characterize thermal response of tank waste during the sluicing operation to define operating limits in terms of maintaining waste subcooling and thus eliminating possibility of steam bumping.
2. Sluicing ventilation system can be operated in three modes:
 - a) Normal day-to-day configuration.
 - b) Pre-sluicing tank chiller system configuration that can subcool bottom waste to near-winter conditions (takes 3 to 4 months and achieves a minimum temperature of 224 °F [4 to 6 °F subcooling]).
 - c) Sluicing configuration for visibility defogging and not heat removal.
3. Waste must remain subcooled at all times during waste retrieval (below local saturation temperature).
4. Rapid sluicing can eliminate the waste subcooling and result in local steam generation in the waste.
5. Incremental retrieval of waste (sluicing 0.3 to 0.9 m [1 to 3 ft]) followed by cooling hold periods of 1 to 2 weeks which allows waste to become significantly subcooled can eliminate the possibility of steam bump.
 - a) First sluice step will remove sludge down to 60-in. level (3/4 to 1 ft) followed by 14 day cooling period.
 - b) Second sluice step will remove an additional 1 ft of sludge followed by 14 day cooling period.
6. Sluicing should be performed with a constant liquid pool level with no waste exposed (except at tank wall) in order to maintain a constant tank waste bottom pressure an ensure accurate level measurements.
 - a) For first sluice, perform at 72 in. (2 to 3 in. covering sludge) which maintains about 6 °F subcooling.
 - b) For second sluice, perform at 60 in., which maintains over 10 °F subcooling.

- c) After second sluice, draw liquid level down to 48 in., which will result in 30 °F subcooling with maximum waste temperature below saturation temperature at atmospheric pressure (eliminates potential steam generation).
 - d) Pool liquid level should be continuously monitored by the submersible slurry pump conductivity probes with periodic verification by ENRAF measurements.
7. Post-sluicing dry waste steady-state analyses indicate sufficient heat can be removed to eliminate the need for further water additions:
- a) Non-sluiceable hard pan should contain very little heat; most tank heat in waste above this region.
 - b) If 2 ft (33%) of waste retrieved and active ventilation is maintained, water additions can be eliminated.
 - c) If 4 ft (66%) of waste retrieved with passive ventilation, water additions can be eliminated.
 - d) Waste dry out will proceed slowly; time to reach peak waste temperatures may exceed 10 years.

Attachment 2

IMPORTANT CONCLUSIONS

WHC-SD-W320-TI-007, Rev 0, "Flammable Gas and Steam Controls for WRSS Operation, Project W-320"

1. Operational control philosophy is that following a significant amount of waste retrieval, sluicing operations will be halted and waste analysis will be performed during the shutdown.
 - a) Approach calls for a sequenced incremental retrieval of waste from tank C-106 (by volume) followed by a monitoring period during which waste behavior will be observed.
 - b) 1-ft depth waste retrieval increment represents a volume of about 25,000 gallons.
 - c) Minimum hold or monitoring period of 2 weeks.
2. Ability to detect a developing flammable gas retention condition in tank AY-102 is also of concern.
 - a) Limiting waste retrieval from C-106 to 50% of total will eliminate flammable gas retention in AY-102 and subsequent gas release event (GRE) concern.
 - b) After 50% waste retrieval has been achieved, WRSS system will be shutdown and tank AY-102 will be monitored for slurry growth .
3. General control actions will place 1-2 in. supernate above waste in C-106 (6 in. nominally) and AY-102 supernate level will be held constant during sluicing period (controlled level sluicing).
 - a) Increments of 1-ft depth of waste will be removed by sluicing.
 - b) Then 6 in. supernate pumped to C-106 from AY-102 and temperatures of thermocouple trees 8 and 14 monitored for one week.
 - c) Then C-106 supernate volume pumped down until 1-2 in. remains over solid waste; temperatures monitored for one week to verify adequate waste subcooling.
 - d) Sluicing sequence repeated.
4. To mitigate against tank C-106 flammable gas plume generation:
 - a) Suggested that HVAC system be operational during and following termination of sluicing operations.
 - b) Standard hydrogen monitoring system (SHMS) will monitor C-106 for indication of hydrogen being released into head space.

5. To mitigate against tank AY-102 flammable gas retention/release:
 - a) Gas retention monitoring will be performed during each sluicing incremental hold period (for slurry growth by observation during the hold period).
 - b) 1-ft waste removal increment and 2-week hold period will be maintained beyond 50,000 gal waste retrieval specification.
6. Upon satisfactory removal of 50% (100,000 gal) waste from C-106, a heat balance measurement will be made to see if sufficient source term has been removed.

Attachment 3

IMPORTANT CONCLUSIONS

WHC-SD-WM-ER-594, Rev 0, "Evaluation of Recommendation for Addition of Tanks to the Flammable Gas Watch List"

1. Additional tanks should not be recommended for the Flammable Gas Watch List. (FGWL).
 - a) Results of analyses are not sufficiently definitive because models are too primitive and current data lacks precision.
 - b) FGWL tanks do not include C-106 or AY-102.
 - c) 32 candidate tanks for FGWL do not include C-106 or AY-102.
2. Tanks with a significant potential for radioactive release are controlled under the USQ process for flammable gas.
3. Level perturbations induced by atmospheric pressure changes [Barometric Pressure Effect (BPE)] considered possible basis for establishing flammable gas retention by waste.
4. Level perturbations by continuing surface level increase [Surface Level Rise (SLR)] considered possible basis for establishing flammable gas retention by waste.
5. Tank liquid or solid waste surface level can be measured by:
 - a) FIC gauge.
 - b) ENRAF gauge.
 - c) Manual tape.
 - d) Neutron logging instrumentation.
6. Computational model relates waste surface linear displacement measurement with volume of retained gas:
 - a) Concentration of flammable gas in tank headspace following postulated gas release event (GRE) depends on fraction of gas trapped in waste that is released (assumed 25%) and fraction of gas released that is flammable (assumed 97% hydrogen).
 - b) Criterion for candidates to FGWL is general flammable gas concentration in headspace assumed to be a hazard when greater than 25% of the Lower Flammability Limit (LFL).
 - c) Reexamination suggests 100% of the LFL more appropriate requirement for determining serious release consequences.
 - d) Non-flammable gases (e.g., nitrogen) normally constitute at last 50% of released tank gas; assumption of 97% hydrogen concentration is far

too conservative (nominal 25% hydrogen with bounding value of 50% expected).

- e) Current methods yield "ballpark" estimates of the volume of trapped gas.
7. General view is that buoyancy-induced rollover is the only mechanism likely to produce rapid release of large fraction of waste-retained flammable gas:
- a) Rollovers occur in tanks with a supernatant liquid depth approximating the depth of settled waste solids.
 - b) Effects of massive release of plumes of waste-retained flammable gas stimulated by intrusive activities (e.g., sluicing) have not been considered.
8. Consideration of released flammable gas plume burn is very important, versus consideration of average dome space flammable gas concentration.



Department of Energy
 Richland Operations Office
 P.O. Box 550
 Richland, Washington 99352

MAY 31 1996

96-WSD-062

Dr. A. L. Trego, President
 Westinghouse Hanford Company
 Richland, Washington

Dear Dr. Trego:

**DIRECTION FOR RISK EVALUATION GUIDELINES AND OFFSITE MAXIMUM EXPOSED
 INDIVIDUAL (MEI) LOCATION**

- References:
1. Memorandum from R. Guimond, HQ, to Manager, RL, "Interim Radiological Dose Acceptance Criteria for the Hanford Tank Farms Safety Analysis," dated April 4, 1996.
 2. Letter from A. Sidpara, RL, to A. L. Trego, WHC, "Risk Acceptance Criteria for Tank Farm Operation," dated June 14, 1995.
 3. Letter from W. B. Scott, RL, to President, WHC, "Clarification of Hanford Site Boundaries for Current and Future Use in Safety Analysis," #9504327, dated September 26, 1995.
 4. Letter, from P. W. Kruger, RL, to President, WHC, "Further Discussion on Previous Site Boundary Memorandum," #9600588, dated March 5, 1996.

This letter provides direction for use of risk evaluation guidelines and defines the location of the offsite MEI for consideration during preparation of Tank Waste Remediation System (TWRS) safety analyses. Specifically, this direction applies to the safety documentation associated with TWRS projects and the TWRS Basis for Interim Operation (BIO)/Final Safety Analysis Report (FSAR).

The risk evaluation guidelines presented in Reference 1 are effectively the same as those presented in Reference 2 for the offsite receptor. The guidelines presented in Reference 1 are more conservative in application (step function) than those presented in Reference 2 by about a factor of two for the onsite receptor when considering events with an extremely unlikely estimated frequency of occurrence. Very little difference in controls and other mitigative measures required for risk management is expected through application of either set of risk evaluation guidelines.

Dr. A. L. Trego
96-WSD-062

-2-

MAY 31 1996

Therefore, TWRS safety analyses that were initiated for projects prior to issuance of Reference 1 (April 4, 1996) shall continue utilizing the risk evaluation guidelines previously established in Reference 2. Examples of these include those safety assessments in progress for Rotary Mode Core Sampling of Flammable Gas Tanks and Saltwell Pumping of Flammable Gas Tanks. These safety analyses will be revised as required to reflect the risk evaluation guidelines presented in Reference 1 during the first annual update or when incorporated into the TWRS BIO/FSAR unless Reference 1 is superseded.

The TWRS BIO/FSAR will use the risk evaluation guidelines presented in Reference 1. Other safety analyses within TWRS that start after April 4, 1996, shall also use the risk evaluation guidelines presented in Reference 1.

References 3 and 4 identify that, as a public waterway, access to the Columbia River is not controlled by U.S. Department Of Energy, Richland Operations Office (RL). During the performance of safety analyses, the Columbia River must be considered as potentially being the nearest point of uncontrolled public access. This will depend upon the location of the facility or activity being analyzed and associated meteorological parameters.

For TWRS facilities, the near shore of the Columbia River becomes the location of the offsite MEI. Examination of dispersion parameters indicates that the radiological dose consequences for a receptor at this new offsite MEI location compared to the previously defined offsite MEI location would increase approximately 30 percent for events initiated at TWRS facilities in 200W, and approximately 50 percent for events initiated at TWRS facilities in 200E. No additional controls or other mitigative measures required for risk management are expected through application of either offsite MEI location in TWRS safety analyses.

Therefore, TWRS safety analyses that were initiated for projects prior to issuance of Reference 4 (March 5, 1996) shall continue utilizing the previously defined offsite MEI location (Hanford Reservation Boundary). These safety analyses will be revised during the first annual update or when incorporated into the TWRS BIO/FSAR as required to address the new offsite MEI location resulting from consideration of the Columbia River as the nearest point of uncontrolled public access.

The TWRS BIO/FSAR will use the new offsite MEI location resulting from consideration of the Columbia River as the nearest point of uncontrolled public access. Other safety analyses within TWRS that start after March 5, 1996, shall also use the new offsite MEI location.

Dr. A. L. Trego
96-WSD-062

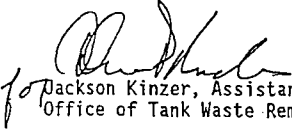
-3-

MAY 31 1995

The above direction will result in a smooth and consistent transition to these new requirements while maintaining adequate risk management. This direction does not impact current project safety documentation preparation activities. Westinghouse Hanford Company shall expeditiously submit a change request for RL approval addressing the impact of the above direction on the TWRS BIO/FSAR preparation activity.

If you have any questions, please contact Carol Sohn on 376-8523.

Sincerely,


for Jackson Kinzer, Assistant Manager
Office of Tank Waste Remediation System

WSD:MJR

cc: R. F. Bacon, WHC
M. L. Cowan, WHC
G. L. Dunford, WHC
G. R. Franz, WHC
R. S. Popielarczyk, WHC

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CORRESPONDENCE DISTRIBUTION COVERSHEET

Author	Addressee	Correspondence No.
J. P. Harris 372-1237	B. L. Nicoll, RL	9652542

Subject: PROJECT 93E-EWW-320, "TANK 241-C-106 SLUICING," MODIFICATION OF
SLUICING FLUID SELECTION

INTERNAL DISTRIBUTION

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		A. M. Umek	H6-35
		J. H. Wicks	R2-50
		GAM LB/FILE	S2-48
		Project Files	R1-29

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P.O. Box 1970 Richland, WA 99352

June 10, 1996

9652542

Mr. B. L. Nicoll, Project Director
TWRS Waste Retrieval
U.S. Department of Energy
Richland Operations Office
Richland, Washington 99352

Dear Mr. Nicoll:

PROJECT 93E-EWW-320, "TANK 241-C-106 SLUICING," MODIFICATION OF SLUICING
FLUID SELECTION

- References:
1. Letter, C. A. Augustine, WHC, to R. L. Long, RL, "Project 93L-EWW-320, Tank 241-C-106 Sluicing - Sluicing Fluid Baseline Change to Corrosion Inhibited Water," 9457345, dated November 17, 1994.
 2. J. P. Sederburg, WHC-SD-WM-ES-290, Rev. 2, "Chemical Compatibility of Tank Wastes in 241-C-106, 241-AY-101, and 241-AY-102," dated August 24, 1994.
 3. Letter, S. W. Bork and R. A. Harrington, ICF KH, to J. W. Bailey, WHC, "Project W-320 Tank 106-C Waste Retrieval Study Analysis Session Report," W-320-04, dated August 17, 1993.

This letter documents the technical baseline change to Project W-320, "Tank 241-C-106 Sluicing", changing the sluicing fluid from corrosion inhibited water to Tank 241-AY-102 (AY-102) supernatant. The technical basis and justification are discussed below, as well as background and insight into the selection changes experienced during the project's formulation, design, and construction phases.

Originally, Tank 241-AY-101 (AY-101) supernatant was selected as the sluicing fluid of choice, based on the outcome of a Study Analysis Session (SAS) facilitated by Inner City Fund - ICF Kaiser Hanford Company (ICF KH) in 1993 (Reference 3). This SAS utilized Value Engineering principles to consider compatibility issues in connection with other issues to make a decision about the designation of a receiver tank and the sluicing media to be used by the project. These issues included schedule, likelihood of success, program interfaces, initial cost, minimization of liquid transuranic (TRU) waste, support of overall waste minimization, life cycle costs, and tank configuration. The major criterion for selection of the AY-101 fluid as the optimal sluicing media was the desire to minimize complexed

Mr. B. L. Nicoll
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June 10, 1996

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waste volume, since both wastes had been classified as containing organic complexants.

In November, 1994, Reference 1 was sent to the U.S. Department of Energy, Richland Operations Office (RL) Tank Waste Projects Division, outlining a change in the baseline sluicing fluid from AY-101 supernatant to corrosion inhibited water. This change was predicated on ammonia concentration uncertainties in the new ventilation system stack exhaust as a result of potential ammonia concentrations in the AY-101 supernatant. Certain AY-101 characterization data suggested supernatant ammonia concentrations which could have been high enough to be a significant concern. Using that data, analyses of ammonia transfer into the atmosphere of Tank 241-C-106 (C-106) had been unable to preclude the possibility of ammonia releases from the new ventilation system which would be dangerous to on-site personnel.

As a result of this discovery, other sluicing fluid options were evaluated. The project's Chemical Compatibility Analysis Reference 2, had been revised prior to this (in August 1994) to evaluate a total of four potential sluicing fluids as a result of questions/comments related to alumina precipitates in the AY-101 fluid. These options included: 1) sluicing with AY-101 supernatant, 2) sluicing with 2.5 molar hydroxide solution, 3) sluicing with other dilute or concentrated wastes such as AY-102 or AN-106, respectively, and 4) sluicing with corrosion inhibited raw water.

In addition to the results of the compatibility analyses, which indicated that any four of the options were satisfactory from a compatibility standpoint, programmatic drivers were included in the evaluation. At that time, Westinghouse Hanford Company (WHC) Tank Farm Transition Projects East Tank Farm Operations held discussions with project management staff in which it was requested that 102-AY supernatant be made available for future 242-A Evaporator campaigns. The conclusion was therefore reached that the W-320 sluicing fluid be changed to corrosion inhibited water. Concurrence was received from the WHC organization responsible for waste volume projections, which assessed that tank space was available to support this change. Other sluicing fluid options, such as the use of Liquid Effluent Retention Facility (LERF) waste for recycle back to AY-102, were evaluated and rejected due to an ammonia content similar to that of AY-101.

Up to this point, project environmental and safety documentation had not specified a particular sluicing fluid. Rather, documentation referenced the compatibility study and stated that one of the "compatible" fluids would be used as the sluicing medium. Comments received during the second tier review of the project's Safety Assessment (SA) Document (WHC-SD-WM-SAD-024) requested specificity regarding the sluicing fluid. The SA text was modified to denote corrosion inhibited water (the baseline) as the sluicing fluid.

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Following the SA modification, East Tank Farm Operations informed project management staff that AY-102 supernatant was no longer required as an Evaporator feed, and requested that the use of AY-102 supernatant be evaluated as a sluicing fluid. This fluid had already been evaluated in Reference 2 and found to be compatible, and its use would dramatically improve the waste minimization aspects of the retrieval activity. Also, the use of the existing AY-102 supernatant would greatly simplify the preparatory steps for the sluicing retrieval in that a decant and refill of AY-102 with corrosion inhibited water would no longer be required.

Because of the foregoing, it was agreed within WHC that the use of AY-102 supernatant was now the optimal choice, and the technical baseline for the project was changed. The discussion of the sluicing fluid in the project Safety Assessment Document has been modified to reflect the new baseline. Revised pages will be submitted to RL for the document's Tier III reviewers during the next scheduled update (to incorporate completion of comment resolutions) in June, 1996.

If you have any questions on this subject, please contact K. W. Leliefeld at 373-2759.

Very truly yours,



G. A. Meyer, Manager
Waste Retrieval Project
Tank Waste Remediation System

jld

RL - W. Abdul
A. H. Wirkkala
W. R. Wrzesinski

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**Westinghouse
Hanford Company**
**Internal
Memo**

From: Materials and Corrosion Engineering 74A40-96-JLN-006
 Phone: 373-6296 RI-30
 Date: April 16, 1996
 Subject: EVALUATION OF CORROSION STATUS OF 241-AY-102

To: L. A. Tusler R2-11

cc:

T. M. Blaak	S5-13	D. A. Reynolds	R2-11
K. G. Carothers	RI-51	W. E. Ross	S5-07
J. M. Jones	S5-13	J. P. Sloughter	R2-54
N. W. Kirch	R2-11	M. J. Sutey	T4-07
P. C. Ohl	RI-30	JLN LB/File	

- References:
- (1) Internal Memo, D. L. Herting to J. M. Jones, "Characterization of Sludge Sample from Tank 241-AY-102," 75764-PCS-96-021, dated April 3, 1996.
 - (2) Meeting Minutes, L. A. Tusler to Distribution, "Get-Well Plan on Low pH," meeting date March 4, 1996.
 - (3) Internal Memo, L. A. Tusler to N. W. Kirch, "Double Shell Tank Composition Status - Quarterly Report," 74A30-96-008, dated February 27, 1996.

In response to action item 1 of Reference 2, a corrosion evaluation of the chemistry conditions in 241-AY-101 has been completed. The evaluation is based on the analytical results from a December 6, 1994 sludge sample plus that for the current estimate of the tank waste composition from mass balance calculations (Reference 3). This tank has most recently been corrected from a low hydroxide condition by the addition of 1,700 gallons of 19 molar sodium hydroxide in January, 1996. There are currently no identifiable disqualifying conditions for continued storage of this waste.

The hydroxide, nitrite, and nitrate concentrations used in the corrosion evaluation are shown in the table below. The relative concentrations of these species are prescribed in the double-shell tank corrosion control specifications. The concentrations of other reactive species are used in the evaluation of uniform corrosion rates, but are not reported here. These are available in Reference 1.

L. A. Tusler
Page 2
April 16, 1996

	AY-102 Supernate Calculated	AY-102 Supernate from 12/6/94 Sample	AY-102 Sludge ISL from 12/6/94 Sample
Hydroxide (M)	0.05	0*	0*
Nitrite (M)	0.02	0.0222	0.0217
Nitrate (M)	0.01	0.0093	0.0093
Corrosivity Factor	0.14	0.42	0.43
Minimum Nitrite (M)	0.017	0.015	0.015
% Elongation	>20	>20	>20
Uniform Corrosion, mpy	<1	<1	<1

* Hydroxide concentration below detection limit of 0.00225M
Calculations based on waste at 40°C

In the table above, "Supernate Calculated" refers to the estimated bulk supernate waste composition based on a combination of analytical results and a running mass balance of waste transfer activity in the tank, as reported in Reference 3. This represents the best estimate of current supernate waste composition. The column "Supernate from 12/6/94 Sample" reports the analytical results for the supernate waste from a sample taken December 6, 1994, as reported in Reference 1. It is believed that the "Supernate Calculated" data more accurately represent the current actual supernate composition, since nearly 15 months have elapsed from the time the sample was taken. The tank has been receiving new waste during this time and has had the previous caustic deficiency corrected by the direct addition of sodium hydroxide.

The column "Sludge ISL from 12/6/94 Sample" reports the analytical results for the sludge interstitial liquid (ISL), as reported in Reference 1. The ISL composition is used for the corrosion evaluation because it is believed to provide the controlling chemistry for the corrosion reaction, rather than the bulk sludge chemical composition. The relationship between changes in sludge ISL chemistry and changes in bulk supernate chemistry from waste additions is unknown. However, it is expected that changes in the sludge ISL chemistry will lag behind changes in the supernate chemistry because such changes will be governed more by diffusion through the sludge layer than by mixing. Thus the sludge ISL sample analytical results may still most accurately represent the current corrosion conditions at the tank bottom, even though the supernate chemistry has changed significantly from the time of sampling.

The Corrosivity Factor utilizes the ratio of nitrate to nitrite and hydroxide concentrations to estimate the tendency to stress corrosion crack the tank walls. Based on an assessment of single shell tank failures, corrosivity factors of greater than 2.5 are cause for concern and immediate corrective action. There are no corrosivity factors greater than 2.5 calculated above.

L. A. Tusler
Page 3
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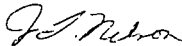
74A40-96-JLN-006

The Minimum Nitrite calculation estimates the lowest nitrite concentration required to inhibit nitrate induced pitting. This estimation is based on an algorithm developed from laboratory studies at the Savannah River Site (SRS). There are no nitrite values below the minimum. Moreover, the published algorithm includes a 50% factor of safety for the recommended limits, i.e. the calculated minimum nitrite values are 50% higher than the estimated critical value to preclude pitting.

The Percent Elongation evaluation utilizes a regression fit of recent Pacific Northwest National Laboratory (Pacific Northwest) laboratory test results on stress corrosion cracking in dilute waste systems. Previous laboratory studies at the SRS have identified elongations of less than 13% as indication of stress corrosion cracking. Application of the Pacific Northwest data to the SRS criterion does not indicate stress corrosion cracking for the above waste systems. The Pacific Northwest data were generated at a significantly higher temperature (92°C) than found in this waste tank. Nonetheless the results provide a useful independent corroboration to the corrosivity factor calculation.

The estimated uniform corrosion rates lie within acceptable ranges. The uniform corrosion rate model is highly dependent on temperature and hydroxide concentration. In the case where hydroxide is reported conservatively as 0 (below detection limit), the model cannot accept this concentration as an input. Extrapolation of the model output for hydroxide concentrations below the 0.0001 M input limit indicates an acceptable uniform corrosion rate through at most one order of magnitude decrease in hydroxide concentration (0.00001 M). Reliable estimations of corrosion rates below this limit are not possible without further study. Reference 1 reports an average supernate pH of 10.4. For dilute solutions this would calculate to a hydroxide concentration of 0.00025 M. This is greater than the above estimating limit, indicating the output of the model may still have some validity. A temperature of 40°C was used as a conservative upper limit for the corrosion calculations.

Attached are the worksheets for the above evaluation. If you have any questions, please feel free to call me on 373-6296.

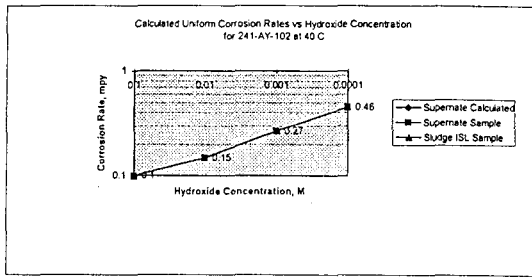


J. L. Nelson, Senior Principal Engineer
Materials and Corrosion Engineering
vmm

Attachment

PNL Uniform Corrosion Rate Model
Estimated uniform corrosion rates at 40 C, mpy
vs. OH concentration

OH (M)	Supernate Calculated	Supernate Sample	Sludge ISL Sample
0.1	0.1	0.1	0.1
0.01	0.15	0.15	0.15
0.001	0.27	0.27	0.27
0.0001	0.46	0.46	0.46



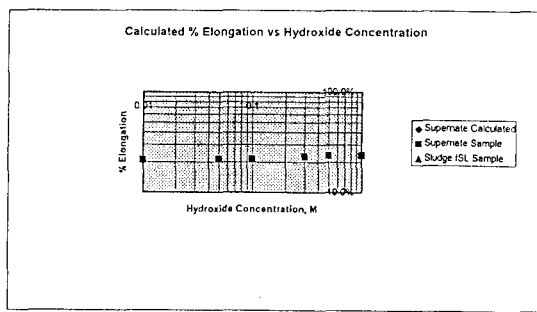
OH	Supernate Calculated	Supernate Sample	Sludge ISL Sample
	0.05	0	0
NO2	0.020	0.022	0.022
NO3	0.010	0.009	0.008
Temp. C	40	40	40

less than detection

	0.14	0.42	0.43
Corrosivity Factor:			
Minimum NO2 required to inhibit NO3 induced pitting:	0.017	0.015	0.015
Maximum temperature to inhibit NO3 induced pitting: (from SRL pitting mode)	42	44	44

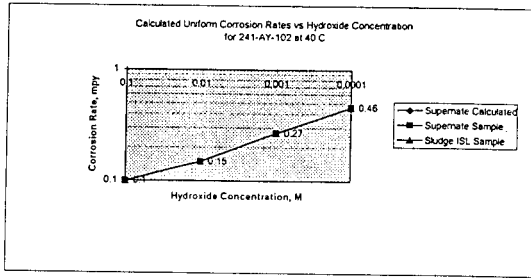
PNL Sludge Washing Study

OH	% Elongation Supernate Calculated	% Elongation Supernate Sample	% Elongation Sludge ISL Sample
0.01	21.1%	21.2%	21.2%
0.05	21.6%	21.6%	21.6%
0.1	22.0%	22.0%	22.0%
0.3	23.0%	23.0%	23.0%
0.5	23.6%	23.6%	23.6%
1	23.7%	23.7%	23.7%



PNL Uniform Corrosion Rate Model
Estimated uniform corrosion rates at 40 C, mpy
vs. OH concentration

OH (M)	Supernate Calculated	Supernate Sample	Sludge ISL Sample
0.1	0.1	0.1	0.1
0.01	0.15	0.15	0.15
0.001	0.27	0.27	0.27
0.0001	0.46	0.46	0.46



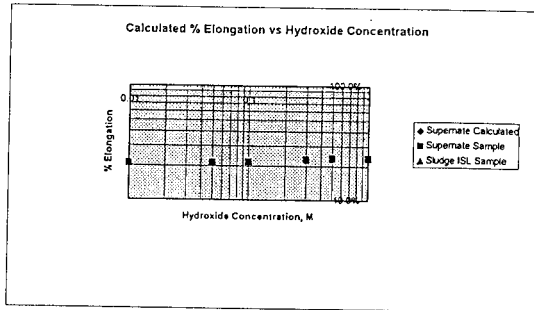
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	0.05	0	0
NO2	0.020	0.022	0.022
NO3	0.010	0.009	0.009
Temp. C	40	40	40

less than detection

Corrosivity Factor:	0.14	0.42	0.43
Minimum NO2 required to inhibit NO3 induced pitting:	0.017	0.015	0.015
Maximum temperature to inhibit NO3 induced pitting: (from SRL pitting model)	42	44	44

PNL Sludge Washing Study

OH	% Elongation Supernate Calculated	% Elongation Supernate Sample	% Elongation Sludge ISL Sample
0.01	21.1%	21.2%	21.2%
0.05	21.6%	21.6%	21.6%
0.1	22.0%	22.0%	22.0%
0.3	23.0%	23.0%	23.0%
0.5	23.6%	23.6%	23.6%
1	23.7%	23.7%	23.7%



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DON'T SAY IT --- *Write It!*

DATE June 25, 1996

TO: John Bailey

FROM: D. Nguyen

cc: Dean Jones

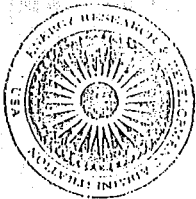
373-2398

SUBJECT: W-320 Pressure Pulse

John,

I found some information on the mechanical properties of HEPA filter that I believe will answer the question that you have regard to the 2 psi. overpressure. Please review the attached document and let me know if you would like anymore information. Thank you

Danny



Nuclear Air Cleaning Handbook

C.A. Burchsted
A.S. Fuller
J.E. Kahn

C. 16

NUCLEAR AIR CLEANING HANDBOOK

DESIGN, CONSTRUCTION, AND TESTING OF
HIGH-EFFICIENCY AIR CLEANING SYSTEMS
FOR NUCLEAR APPLICATION

C. A. Burchsted

J. E. Kehn

A. B. Fuller

Contract No. W-7405-eng-26

OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee 37830
OPERATED BY UNION CARBIDE CORPORATION
FOR THE ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

PROPERTY OF U.S. GOVERNMENT

3.2.3 Weight of HEPA Filters

The weight of filter elements is an important factor in design and maintenance. Table 3.2 gives the clean-filter weight of open-face and enclosed rectangular models. Dirty-filter weights, for design purposes, are approximately 4 lb more per 1000 cfm of rated capacity.

3.2.4 Mechanical Properties

Other factors (heat, moisture) being equal, wood-cased filters are preferred to steel-cased filters because of their greater rigidity, superior vibration-damping characteristics, greater corrosion resistance, and greater corner strength. Common practice in nuclear plant exhaust systems is to compress filter gaskets by 80% or more. This amount of gasket compression requires a clamping force of at least 18 lb per square inch of gasket surface, or a total load of 1250 lb or more on the frame of a 1000-cfm filter unit. Because its section modulus is nearly 20 times that of a steel case, the wood case is better able to withstand such high compressive, axial loads on the case panels. The wood case, with properly constructed (rabbeted) corners, also has about twice the corner strength of a steel case of the same size and is therefore better able to withstand racking or skewing when subjected to a force couple. Racking, which frequently occurs during handling, shipping, and installation, can damage either the filter medium or the seal between the core and case, or both. Face guards, consisting of hardware cloth or expanded-metal screens fastened to each face of the filter, increase the resistance to racking or skewing.

Resistance to shock pressures is important in a HEPA filter because it is often the final barrier between the contaminated space and the atmosphere. The shock overpressure resistance of open-face rectangular filters, based on tests by the U.S. Navy,¹² is given in Table 3.3 and Fig. 3.4. The recommended values are the maximum shock overpressure that the filters should withstand without visible damage or loss in filtration efficiency when exposed to a shock of approximately 50 msec duration. Filters with face guards on both faces have about 40% greater shock resistance than those without. Dirt-loaded filters in the Navy tests exhibited about 15% less shock resistance than clean filters. At overpressures of 0.5 to 1.0 psi greater than the failure value, the filter medium burst on the downstream side of the pleats; at overpressure of 2 psi greater than the failure value, extensive damage to the core occurred; and at 5 psi, blowout of the entire filter core occurred.¹² The greater shock resistance of filters with face guards is significant. The AEC, and more recently ERDA and NRC, has long advocated face guards on HEPA filters to minimize damage to the fragile core during handling and installation. The additional factor of higher shock overpressure resistance gives added weight to this recommendation. The shock overpressure resistance of enclosed filters is probably less than that of open-face filters, because the shock loading will be concentrated at the center of the core. However, no tests have been made to verify this phenomenon.

Another important property of HEPA filters is their ability to withstand continuous overpressure. By

Table 3.2. Weight of unused HEPA filters

Filter size (in.)	Nominal airflow capacity (cfm)	Approximate weight (lb) of filters with —	
		Wood case	Steel case
Open-face			
8 × 8 × 3 $\frac{1}{4}$	25	2	3
8 × 8 × 5 $\frac{1}{4}$	50	3.6	5.8
12 × 12 × 5 $\frac{1}{4}$	125	4.3	7.3
24 × 24 × 5 $\frac{1}{4}$	500	17	22
24 × 24 × 11 $\frac{1}{2}$	1000	32	40
Enclosed			
8 × 8 cross section	25	5	9
8 × 8 cross section	50	7	10.5
12 × 12 cross section	125	17	20
24 × 24 cross section	500	64	72
24 × 24 cross section	1000	78	95

Table 3.3. Shock overpressure resistance of open-face HEPA filters

Filter dimensions (in.)		Overpressure (psig)		
		Overpressure at failure*	Recommended design limit for used filters	
Face	Depth		With face guards	Without face guards
8 × 8	3 1/16	3.7	*	2.0
8 × 8	5 7/8	4.5	*	2.5
12 × 12	5 7/8	3.6	*	2.0
24 × 24	5 7/8	2.2	1.7	1.2
24 × 24	11 1/2	3.2	2.7	1.8

*Clean filter with 4- by 4-mesh face guards on both faces.

*Face guards not available.

Source: W. L. Anderson and T. Anderson, "Effect of Shock Overpressure on High Efficiency Filter Units," *Proc. 9th AEC Air Clean. Conf.*, USAEC Report CONF-660904, 1966.

specification, new HEPA filters must have sufficient structural strength to withstand a continuously

applied overpressure of 10 in.wg. or higher, for at least 15 min without visible damage or loss of efficiency. For used filters, a value of 8 in.wg is recommended for design or planning purposes. In addition, the filter should be able to withstand the considerably higher, but short duration, overpressures that might be encountered in a tornado or when a damper inadvertently slams shut in the duct system. Although the design basis tornado specifies an overpressure of 3 psi for a period of 3 sec,¹³ it is unlikely that the HEPA filters would be subject to such a condition because of the attenuating effects of the stack, ductwork, and fans. Tests at Los Alamos showed that an 8 × 8 × 3 1/16 in. HEPA filter could withstand a 9-sec pressure pulse during which the maximum pressure of 3 psi was held for 3 sec without visible damage or reduction in efficiency.¹⁴ Comparison of these results with the data of Table 3.3 indicates that the 24 × 24 × 11 1/2 in. filter can probably withstand a 9-sec pressure pulse of 2.5 psi, which is probably substantially worse than what the filter would experience in the event of a tornado.

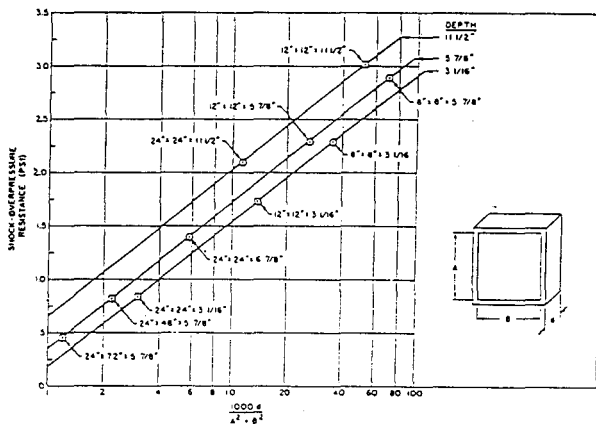


Fig. 3.4. Shock-overpressure resistance of clean HEPA filters (separator type) as a function of size. From C. A. Burchsted, "Environmental Properties and Installation Requirements of HEPA Filters," *Proc. Symp. Treat. Airborne Radioact. Wastes*, International Atomic Energy Agency, Vienna, 1968.

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DATE: July 9, 1996
TO: John Harris, WHC
FROM: Marty Plys *Marty Plys*
SUBJECT: Hypothetical AY-102 Burn Analysis

1.0 SUMMARY

A hypothetical flammable gas burn in AY-102 is analyzed here to illustrate the potential consequences. The key feature of the analysis is that combustion would be incomplete, and the pressure rise is calculated for bounding combustion completeness fraction, assumed here to be 10%. This yields a pressure rise of 1.4 psig, well below the 4.3 psig HEPA failure threshold.

2.0 DATA

From an electronic mail communication, the AY-102 headspace is at 25% of the LFL, i.e. 1% hydrogen, when 1000 SCF of gas containing 50% hydrogen are released, and therefore the headspace volume is 49,500 SCF or 1400 cubic meters. Also from the communication, the HEPA filter can withstand a headspace pressure of 4.3 psig. From other personal communications, there are 500 SCF of stored gas per inch of pressure rise, so 1000 SCF is equivalent to a 2 inch rise.

Per my previous memorandum, gas from C-106 has a nominal composition of 54% hydrogen, 31% methane, and 15% ammonia, and the corresponding heat of reaction is 426.8 MJ/kg-mole; pure hydrogen has a heat of reaction of 241.8 MJ/kg-mole, so clearly the C-106 case is limiting. From my previous work also, a good heat capacity for the gas is 30 kJ/kg-mole-K. Finally, also from my previous work, incomplete combustion is expected when the gas concentration falls below 7%.

3.0 INCOMPLETE COMBUSTION

Gas would be stored in a rather even distribution in the sludge in AY-102, and released incoherently over a time interval of minutes and over much of the supernatant surface area, per the physical phenomena of rollovers commonly observed. This means that the released gas

would mix intimately with headspace air to form a flammable cloud near the waste surface, but further mixing would reduce the gas concentration in the cloud. The physical picture of gas mixing is not that of a well-defined plume released at a particular, limited area which entrains surrounding gases, but rather a very large number of bubbles acting as sources for tiny plumes distributed over much of the waste surface. In particular, for a release of 1000 SCF of pure flammable gas corresponding to a 2 inch level rise, dilution to the LFL would occur within $(1000/35.29)/(0.04*411) = 1.7$ m if the gas were emitted over the entire waste surface, or within about 3 m if the gas were emitted over a little over half the waste surface.

The flammable gas cloud thus would have a pancake shape, i.e. its height of no greater than about 3 m is much less than its diameter of about 22 m. A flammable gas cloud of higher gas concentration would of course be commensurately shorter, so its aspect ratio would be more skewed. Note that it is conservative to assume that all the gas would be present in one coherent cloud, because over a release time of about one minute the gas can travel farther upward than the cloud layer thickness assumed here. In fact, the presence of a cloud of lean gas is guaranteed by the finite release interval. The real configuration of the "cloud" could just as likely be set of small clouds of flammable mixtures over individual release areas separated by nonflammable gas, and thus again incomplete combustion is the only physically possible phenomena.

It is experimentally observed that the combustion completeness is lower for systems with smaller aspect ratios (height to diameter ratios) than for spheres or vertically oriented cylinders, and physical models can adequately account for the effect of geometry [Plys, 1988A and B]. Based on the experience of this author, a combustion completeness of only several percent would be expected for the proposed flammable gas configuration, and ten percent is a bounding figure. Thus, a bounding estimate for the amount of gas that could actually burn is 10% of 1000 SCF, or 2.83 cubic meters. A better estimate could be obtained by using the model described in the references.

4.0 METHOD

A simple method is used here to relate post-combustion pressure to the volume burned. From an energy balance,

$$(1) \quad \frac{T_2}{T_1} = \frac{F_v \Delta h_f}{C_v T_1} + 1$$

where

- C_v = Average heat capacity, J/kg-mole-K
- T_2 = Post-burn temperature, K
- T_1 = Initial temperature, K
- F_v = Fraction of volume occupied gas that burns

$$\Delta h_f = \text{Heat of reaction, J/kg-mole}$$

For the gases of interest, the pre-burn number of gas moles is nearly equal to the post-burn number of gas moles, allowing the expression above. Using the ideal gas law then yields

$$(2) \quad \frac{\Delta P}{P_i} = \frac{F_v \Delta h_f}{C_v T_i}$$

where

$$\Delta P = \text{Pressure rise, Pa}$$

$$P_i = \text{Initial pressure, Pa}$$

5.0 RESULTS

Burning the specified amount of gas yields a pressure rise of:

$$\frac{\Delta P}{P} = \left(\frac{2.83 \text{ m}^3}{1400 \text{ m}^3} \right) \frac{424.8 \times 10^4 \text{ J/kg-mole}}{(3003 \text{ J/kg-mole K})(300 \text{ K})} = 0.096$$

or about 1.4 psig.

6.0 REFERENCES

Martin G. Plys, memorandum to John Harris and John Conner, Westinghouse Hanford Company, Hypothetical C-106 Retrieval-Induced Gas Release and Combustion, June 18, 1996.

Martin G. Plys et al, "A Flammability and Combustion Model for Integrated Accident Analysis," Proc. Int. Conf. Thermal Reactor Safety, Avignon, France, Oct. 2-7, 1988 (A).

Martin G. Plys and Robert D. Astleford, Modifications for the Development of the MAAP-DOE Code, Volume III: A Mechanistic Model for Combustion in Integrated Accident Analysis, DOE/ID-10216 Vol. III, November, 1988 (B).

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Fauske & Associates, Inc.

DATE: July 23, 1996
TO: John Harris, WHC
FROM: Marty Plys *Marty*
SUBJECT: Hypothetical AY-102 Burn Analysis, Revised

1.0 SUMMARY

A hypothetical flammable gas burn in AY-102 is analyzed here to illustrate the potential consequences. The key feature of the analysis is that combustion would be incomplete, and the representative combustion completeness fraction has been discussed with the Chemical Reaction Sub-TAP, yielding an agreed value of 30%. Given a 4.3 psig HEPA failure threshold, the tolerable flammable gas release volume is about 930 SCF, and an equivalent level rise is about 1.85 inches.

2.0 DATA AND ASSUMPTIONS

From an electronic mail communication, the AY-102 headspace is at 25% of the LFL, i.e. 1% hydrogen, when 1000 SCF of gas containing 50% hydrogen are released, and therefore the headspace volume is 49,500 SCF or 1400 cubic meters. Also from the communication, the HEPA filter can withstand a headspace pressure of 4.3 psig. From other personal communications, there are 500 SCF of stored gas per inch of pressure rise.

From personal communication with Hanford engineers, gas from C-106 has a nominal composition of 54% hydrogen, 31% methane, and 15% ammonia, and the corresponding heat of reaction is 426.8 MJ/kg-mole; pure hydrogen has a heat of reaction of 241.8 MJ/kg-mole, so clearly the C-106 case is more limiting. We do not know what the composition of gas from AY-102 will be, but this heat of reaction is at least representative. A good heat capacity for headspace gas is 30 kJ/kg-mole-K.

A discussion was held with the Chemical Reaction Sub-TAP at WHC on July 23 regarding release morphology and combustion completeness. It was agreed that complete combustion was not expected and that a precise value of the completeness could not be rigorously assigned. However, a value of 30% was agreed upon as representative for this evaluation and 1/3 is used here below.

3.0 METHOD

The post-combustion pressure rise in the headspace may be shown to be given by:

$$(1) \quad \frac{\Delta P}{P} = \frac{F_v \Delta h}{C_v T_i}$$

where

ΔP = Pressure rise, Pa

P = Initial pressure, Pa

C_v = Average heat capacity, J/kg-mole-K

T_i = Initial temperature, K

F_v = Fraction of volume occupied gas that burns

Δh = Heat of reaction, J/kg-mole

For the gases of interest, the pre-burn number of gas moles is nearly equal to the post-burn number of gas moles, allowing the expression above, and for the moderate temperature change a constant specific heat is appropriate.

4.0 RESULTS

Allowing a pressure rise of 4.3 psig yields a burned flammable gas volume fraction:

$$F_v = \left(\frac{4.3}{14.5} \right) \frac{(30 e 3)(300)}{(426.8 e 6)} = 6.25 e - 3$$

Multiplying by the headspace volume of 1400 cubic meters and by 3 for the combustion completeness yields a total release volume of 26.3 cubic meters or about 927 SCF, which at 500 SCF/inch is equivalent to a level rise of 1.85 inches.



Fauske & Associates, Inc.

DATE: August 9, 1996
 TO: John Harris & John Conner - WHC
 FROM: Martin G. Plys & Boro Malinovic ^{BM} *Maly*
 SUBJECT: Incomplete Combustion Model

This memorandum discusses the FAI incomplete combustion model and its application to C-106 and AY-102. The model and its validation are described in detail in the references.

1.0 FAI Incomplete Combustion Model

The FAI incomplete combustion model is strictly applicable for premixed gases. It accounts for:

Combustion morphology - experimental observation of the behavior of the burned gases, which form a fireball that grows and accelerates upward from the ignition point,

Gas composition - which affects the flame speed,

Geometry - which affects the distance a flame front travels before quenching, and includes the effect of the height/diameter aspect ratio,

Turbulence - which affects the burning rate by increasing entrainment, and

Temperature - which affects the flame speed but is unimportant for this application.

Mathematical details of the model are contained in the references.

The model was validated for experimental data on a variety of scales in order to determine appropriate coefficient values for reactor safety application. The key finding was

that turbulent gases required larger values of the flame flux multiplier than quiescent gases in order to match the combustion completeness.

Recall that incomplete combustion is expected when the well-mixed hydrogen concentration is below about 8%. In the discussion below, it is assumed that the gas release volume is low enough that the well-mixed concentration is below the lean flammability limit of 4%, so that flammability is only possible in the first place in a fraction of the tank headspace where released gases initially mix with headspace gases.

2.0 Tank Application Versus Experiments

The most important aspects of Hanford tank application are:

1. Geometry. Tank headspaces have relatively small height/diameter aspect ratios. This leads to a low combustion completeness because a growing, accelerating fireball will only occupy a small fraction of a volume with large radial extent, whereas it could occupy most of a volume whose radial extent equals the fireball radius. During incomplete combustion, quenching occurs at the tank walls and dome.
2. Turbulence. Some turbulence is expected as lighter flammable gases mix with and rise upward into heavier headspace gases; this promotes greater combustion completeness.
3. Nonuniform concentration. Concentrations are clearly nonuniform in the mixing region, with the largest concentrations of flammable gas being at the waste surface. If the release is over a non-trivial fraction of the tank surface area, as with a rollover GRE, then mixing of the rising gases occurs with overlying headspace gases and entrainment from the perimeter is negligible; a discrete plume where perimeter entrainment is important is not applicable for a rollover GRE case. The flammable gas concentration is fairly uniform at any given axial elevation, and is basically only a function of height. This implies that a fireball originating from an ignition source near the waste surface would rise by buoyancy and eventually attain elevations where the average concentration lies below the LFL, unless the dome were encountered first; quenching would occur in either case.

Compared to the experiments used to validate the model, the Hanford tank aspect ratio implies lower combustion completeness than observed. The nonuniform concentration where fuel content declines with elevation has a similar implication. Turbulence due to

MEMO: Incomplete
Combustion Model

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mixing implies that experiments with quiescent atmospheres would provide a lower bound on combustion completeness, and experiments with fan-induced turbulence would provide an upper bound on combustion completeness.

3.0 Tank Calculations

The FAI model was applied for various headspace heights and a uniformly mixed hydrogen concentration of 6% with results as shown in the table. The turbulent results were calculated using a flame flux multiplier of 10, the value recommended to account for intense turbulence induced by large fans or spray systems. The highest combustion completeness was just under 11%, for a turbulent, well-mixed headspace and a 5 meter vertical distance between the ignition point and dome.

4.0 References

Plys, M.G., et al, "A Flammability and Combustion Model for Integrated Accident Analysis," Proc. Int. Conf. Thermal Reactor Safety, Avignon, France, Oct. 2-7.

Plys, M.G. and Astleford, R.D., "Modifications for the Development of the MAAP-DOE Code Volume III: A Mechanistic Model for Combustion in Integrated Accident Analysis," U.S. Department of Energy Advanced Reactor Severe Accident Program, DOE/ID-10215, Vol. III, November 1988.

MGP/BM:vd1

cc: M. Epstein
H. Fauske
R.E. Henry

Case	Concentration (%)	Flame	Height (m)	Volume (m ³)	T _{start} (s)	T _{end} (s)	Initial H ₂ (kg)	Final H ₂ (kg)	Initial P (x1E5 Pa)	Final P (x1E5 Pa)	Combustion Completeness (%)	Pressure (x1E5 Pa)
1	6	Laminar	3	1233	6.22	7.28	6.21	6.02	1.098	1.159	3.0	0.061
2	6	Laminar	4	1644	8.29	9.59	8.28	7.85	1.097	1.205	5.2	0.108
3	6	Laminar	5	2055	10.36	11.86	10.35	9.54	1.097	1.259	7.8	0.162
4	6	Turbulent	3	1233	6.22	6.92	6.21	5.96	1.099	1.179	3.9	0.08
5	6	Turbulent	4	1644	8.29	9.15	8.28	7.72	1.097	1.237	6.8	0.14
6	6	Turbulent	5	2055	10.36	11.37	10.35	9.24	1.097	1.318	10.8	0.221

**Westinghouse
Hanford Company**
**Internal
Memo**

From: Process Engineering Analysis
 Phone: 376-2527 HO-34
 Date: July 12, 1996
 Subject: W-320 AND W-030 DESIGN INTEGRATION

74A50-96-KS-018

To: J. P. Harris S7-15

cc: W. Abdul	S7-53	D. M. Ogden	H0-34
J. W. Bailey	S2-48	W. J. Powell	H5-49
R. J. Cash	S7-15	P. D. Rice	G3-12
J. C. Conner	A2-25	S. H. Rifaey	R1-56
R. L. Fritz	S2-12	R. L. Schlosser	R1-56
J. R. Kriskovich	S2-24	J. P. Sloughter	R2-54
G. A. Meyer	S2-48	KS File/LB	H0-34

- References:**
- (1) Internal Memo, K. Sathyanarayana to J. C. Conner, "Current Status of Thermal Hydraulics Analysis and results in support of the safety documentation for Project W-320," dated September 20, 1995.
 - (2) Sathyanarayana, K., and Brent C. Fryer, 1996, "Thermal Hydraulic Evaluation of Consolidating Tank C-106 Waste into Tank AY-102," WHC-SD-WM-ER-534, Rev.0, Westinghouse Hanford Company, Richland, Washington.
 - (3) cc:Mail, J. P. Harris, III to K. Sathyanarayana, "Re: AY-102 Ventilation Questions/Answers," dated July 3, 1996.

Purpose:

The purpose of the analysis is to provide a technical basis for using the Project W-030 ventilation system under Project W-320 conditions to limit peak sludge temperatures below ISOR limits.

Problem Description:

The previous thermal-hydraulic analysis was performed to provide a technical basis supporting the transfer of tank C-106 waste into tank AY-102 (Ref. 1). It has been assumed, based on the project assurances, that the project W-030 ventilation system can provide up to about 600 cfm of primary ventilation flow with ambient inlet air temperature and humidity conditions when operated in the once-through mode. Using the same volumetric flow rate, safety analysis calculations (Ref. 2) were also performed for accident conditions such as loss of ventilation and to estimate the floor cooling channel effectiveness. However, now we have been informed (Ref.3) that the W-030 system at best can only provide a total of 500 cfm with 200 cfm of ambient air and 300 cfm of recirculation air flow. The operation of the W-030 system in recirculation or in once-through mode, as pointed out in Reference 2 is less effective in providing cooling compared to the current

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702-A system since air flow rates are lower and the tank inlet air conditions are worse than for the current system. For the same heat and sludge loading conditions, it should be expected that the operation of the W-030 system would increase the sludge peak temperatures and reduce the thermal safety margins available. In order to assess the magnitude of the increase to the earlier estimates of peak sludge temperatures for the consolidated waste in tank AY-102 and to provide data for making engineering judgements to mitigate this problem, several parametric calculations were performed using expected normal and best inlet air flow conditions for the tank (Ref. 3) with the operation of the W-030 system and using increased secondary ventilation air flows for tank floor cooling.

Results:

Steady-state temperature distribution calculations for the consolidated sludge in tank AY-102 were performed assuming that 4.8 ft of C-106 sludge with a heat load of 92,400 Btu/h has been transferred to tank AY-102, and the transferred sludge will settle to twice its original thickness (Fluffiness Factor = 2). This transfer will leave 1.2 ft of bottom sludge having a heat load of less than 40,000 Btu/h in tank C-106. The details of other parameters of the current waste in tank AY-102, tank C-106, and the estimated parameters of the consolidated waste in tank AY-102 are given in Table 1. For a given set of inlet air flow conditions of the primary ventilation system and specified air flow rate of tank floor cooling, the combined waste temperature distribution in tank AY-102 is estimated using cooling channel effectiveness as a parameter. For 2000 and 3000 cfm air flow rates, the floor cooling channel effectiveness values (Ref. 2) were estimated to be about 37% and 32.5%, respectively. For the 2500 cfm flow, it is assumed that the effectiveness will be 35%. The waste saturation temperatures were calculated assuming vapor pressure characteristics of waste as that of water. The Interim Operational Safety Requirements (IOSR) document for the tank farms specifies the limits on sludge peak temperature based on the local saturation temperature/boiling point to eliminate the potential for a tank bump. The peak sludge temperature must be 17 °C (30 °F) less than the local saturation temperature.

The results of the calculations are summarized in the Table 2. The table provides the estimated peak sludge temperatures and the corresponding margin available for each case of air inlet flow conditions of both the primary ventilation flow to the tank dome and the secondary ventilation flow for tank floor cooling. The sludge temperature distribution for average summer inlet flow conditions of 630 cfm flow for the primary ventilation system and 2000, 2500 and 3000 cfm air flow through the tank floor cooling channels is shown in Figures 1 through 3 with cooling effectiveness as a parameter. These air flow inlet conditions correspond to the current 702-A ventilation system or what the new system is supposed to provide if operated in once-through mode. For the W-030 new ventilation system operation, assuming that the primary ventilation air entering the tank will be at 83 °F and 100% relative humidity with a flow rate of 500 cfm and the secondary ventilation flow of 2000, 2500, and 3000 cfm, the results of sludge temperature distribution is shown in Figures 4 through 6, respectively. The sludge peak temperature values have increased by about 7 to 10 °F and therefore,

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Table 1. Tank Waste Parameters of AY-102 and C-106.

1. Current Waste in Tank AY-102

Waste Volume: 812,000 gallons (24.57 ft)
 Sludge Volume: 32,000 gallons (0.97 ft)
 Supernatant Volume: 780,000 gallons (23.6 ft)
 Waste Surface Level: 295 inches
 Tank Heat Load: 33,000 Btu/h

2. Current Waste in Tank C-106

Waste Volume: 219,000 gallons (6.64 ft)
 Sludge Volume: 197,000 gallons (5.97 ft)
 Supernatant Volume: 22,000 gallons (0.67 ft)
 Insoluble Solids Concentration: 48 wt%
 Density of Insoluble Solids: 100.3 lbm/ft³
 Tank Heat Load: 132,400 Btu/h (~110,000 +20%)
 Heat Load Distribution:
 Top Layer: 2.78 ft, 22,147 Btu/h
 Middle Layer: 1.32 ft, 45,738 Btu/h
 Bottom Layer: 1.87 ft, 64,515 Btu/h

3. Consolidated Waste in Tank AY-102

Sludge

Bottom Layer: AY-102 Sludge

Sludge Height: 1 ft

Heat Load: 33,000 Btu/h

Thermal Conductivity: 0.35 Btu/hr-ft-°R

Top Layer: Transferred C-106 Sludge

Sludge Height: 9.62 ft

Fluffiness Factor: 2

Heat Load: 92,400 Btu/h (Heat load remained in C-106 = 40,000 Btu/h)

Thermal Conductivity: 0.43 Btu/hr-ft-°R

Total Waste Volume: 10⁶ gallons (30.0 ft)

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Table 2. Tank AY-102 Consolidated Sludge Peak Temperatures and Potential Margin from Local Saturation Temperature.

Floor cooling channel flow (cu ft/min)	Primary vent flow of 630 cfm at 70 °F and 50% relative humidity		Primary vent flow of 500 cfm at 83 °F and 100% relative humidity		Primary vent flow of 500 cfm at 76 °F and 75% relative humidity	
	Peak sludge temperature (°F)	Margin from local Tsat (°F)	Peak sludge temperature (°F)	Margin from local Tsat (°F)	Peak sludge temperature (°F)	Margin from local Tsat (°F)
2000	201	42	209	32	206	36
2500	195	48	202	40	199	43
3000	190	53	199	42	196	46

correspondingly reduced the margin for example, with 2000 cfm tank floor cooling flow from 42 to 32 °F. Under these primary air flow conditions, it requires that the cooling air flow through the tank floor channels has to be increased up to 3000 cfm to maintain the same margin.

Due to features of the evaporative tower control system, it is reported (Ref. 3) that the W-030 recirculation ventilation air supply to the tank can be as low as 75 °F (saturated). If the recirculation loop is operated at its design flow of 500 cfm with 300 cfm supplied to the tank through the recirculation loop and 200 cfm ambient air flow, then the effective mixed air flow conditions (Ref. 3) will be 500 cfm flow rate at 76°F and 75% relative humidity. Using these tank inlet air flow conditions for the primary ventilation system, the sludge temperature distribution calculations were performed for 2000, 2500, and 3000 cfm secondary ventilation flow rates, and the results are shown in Figures 7 through 9, respectively. As summarized in Table 2, the peak sludge temperatures were reduced by 3 °F and the corresponding improvement in the margin compared to normal operating conditions of the W-030 system. Based on these results, if the W-030 system can be operated to provide these effective inlet flow conditions for the primary air flow, then to maintain the same temperature margin of 42 °F for the peak sludge temperature, the secondary ventilation flow for tank floor cooling should be increased to at least 2500 cfm.


Conclusions:

The peak temperature in the consolidated sludge of tank AY-102 will be about 209 °F with the normal operation of the W-030 new primary ventilation system at design conditions with 100 cfm ambient air flow and 400 cfm recirculation flow having effectively tank inlet flow conditions of 83 °F and 100% relative humidity. This peak temperature corresponds to 2000 cfm secondary ventilation flow for tank floor cooling and the temperature margin from local saturation will be very close to the IOSR requirement of 30 °F. This margin can be improved either by increasing the secondary flow rate and/or operating the W-030 system at best conditions to provide lower temperature

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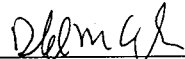
and relative humidity conditions for the tank inlet air flow. Based on the results of these calculations, it is recommended that the secondary ventilation air flow rate be increased from 2000 cfm to 2500 cfm to maintain the same margin for the peak sludge temperature from the saturation value.

 7/12/96
K. Sathyanarayana, Fellow Engineer
Process Engineering Analysis

bab

Attachment

CONCURRENCE:



D. M. Ogden, Team Leader
Process Engineering Analysis

Date: 7/12/96

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74A50-96-KS-018

ATTACHMENT

Figures 1 - 9

Consisting of 10 pages,
including cover page

Figure 1. Temperature Distribution in Sludge Layer of Tank AY-102 with Annulus Ventilation Flow Effectiveness as a Parameter for Secondary Ventilation Flow of 2000 cfm.

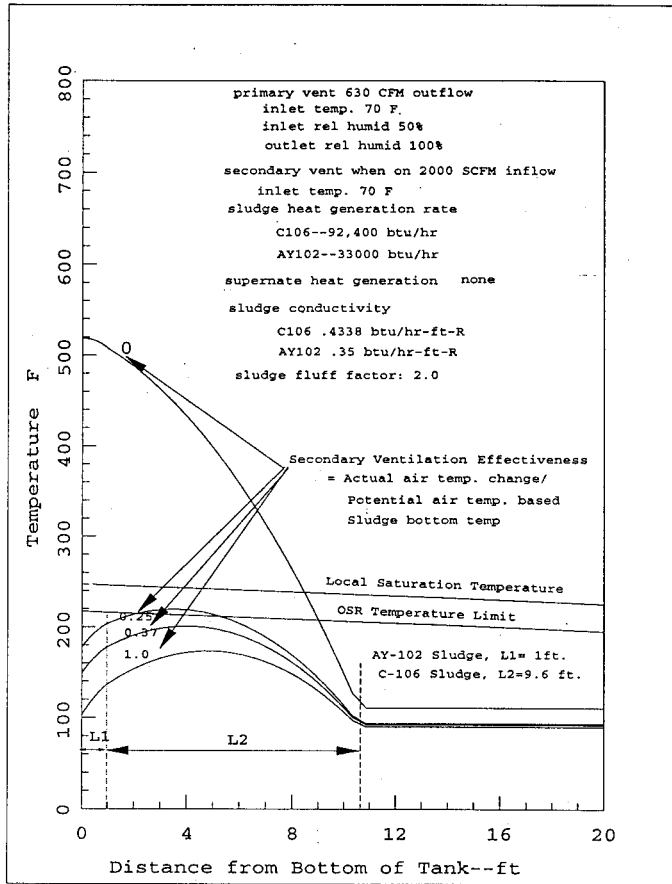


Figure 2. Temperature Distribution in Sludge Layer of Tank AY-102 with Annulus Ventilation Flow Effectiveness as a Parameter for Secondary Ventilation Flow of 2500 cfm.

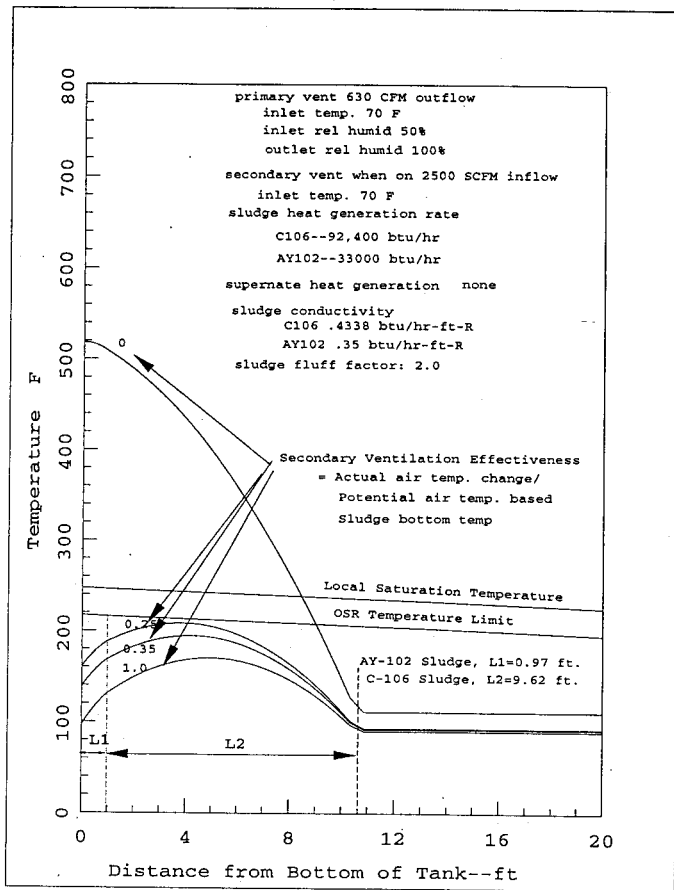


Figure 3. Temperature Distribution in Sludge Layer of Tank AY-102 with Annulus Ventilation Flow Effectiveness as a Parameter for Secondary Ventilation Flow of 3000 cfm.

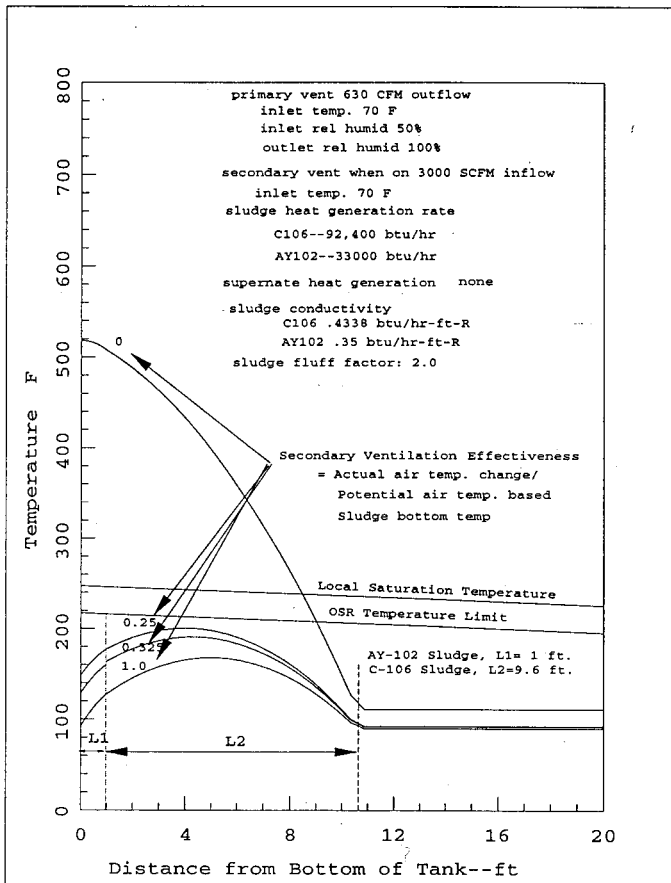


Figure 4. Temperature Distribution for the Combined Sludge of AY-102 and C-106 Using 500 cfm Primary and 2000 cfm Annulus Cooling Flow.

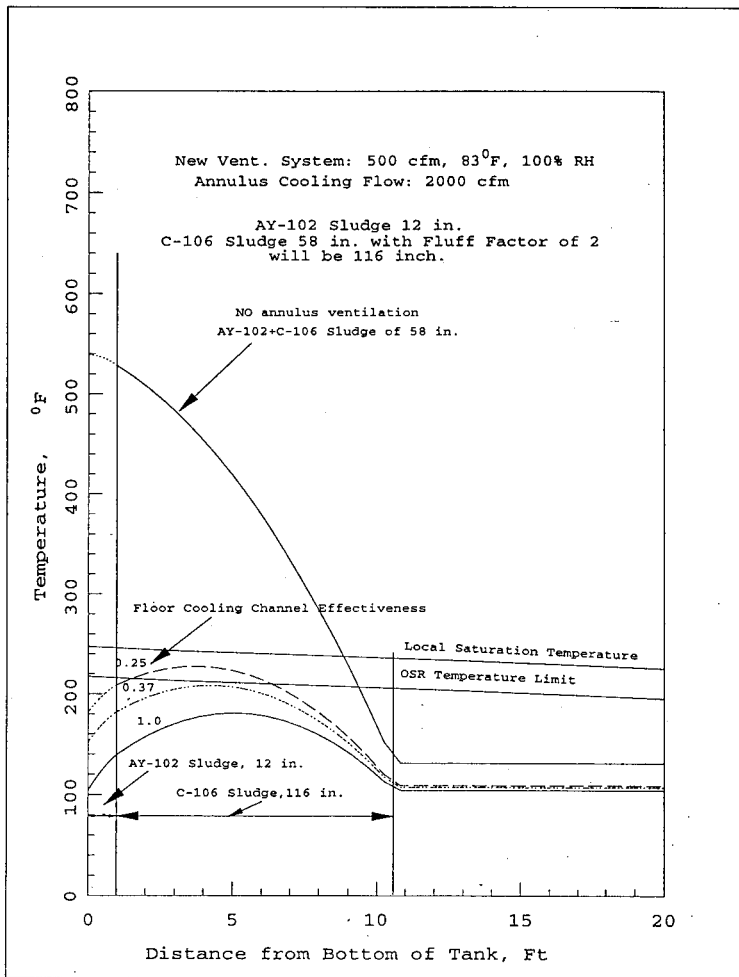


Figure 5. Temperature Distribution for the Combined Sludge of AY-102 and C-106 Using 500 cfm Primary and 2500 cfm Annulus Ventilation Flow.

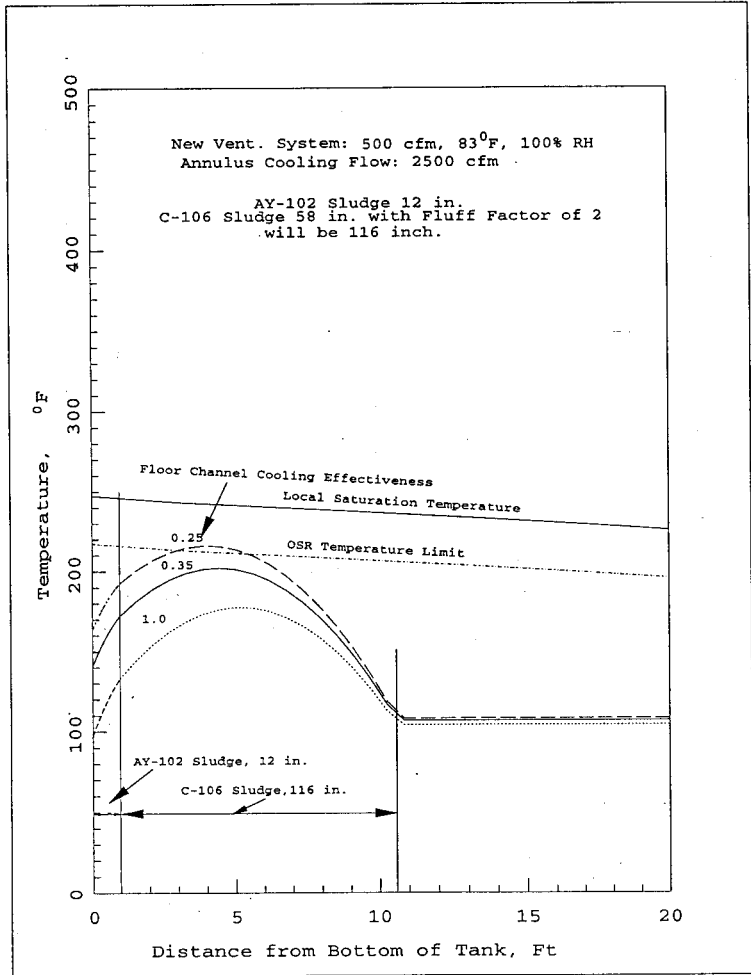


Figure 6. Temperature Distribution for the Combined Sludge of AY-102 and C-106 Using 500 cfm Primary and 3000 cfm Annulus Ventilation Flow.

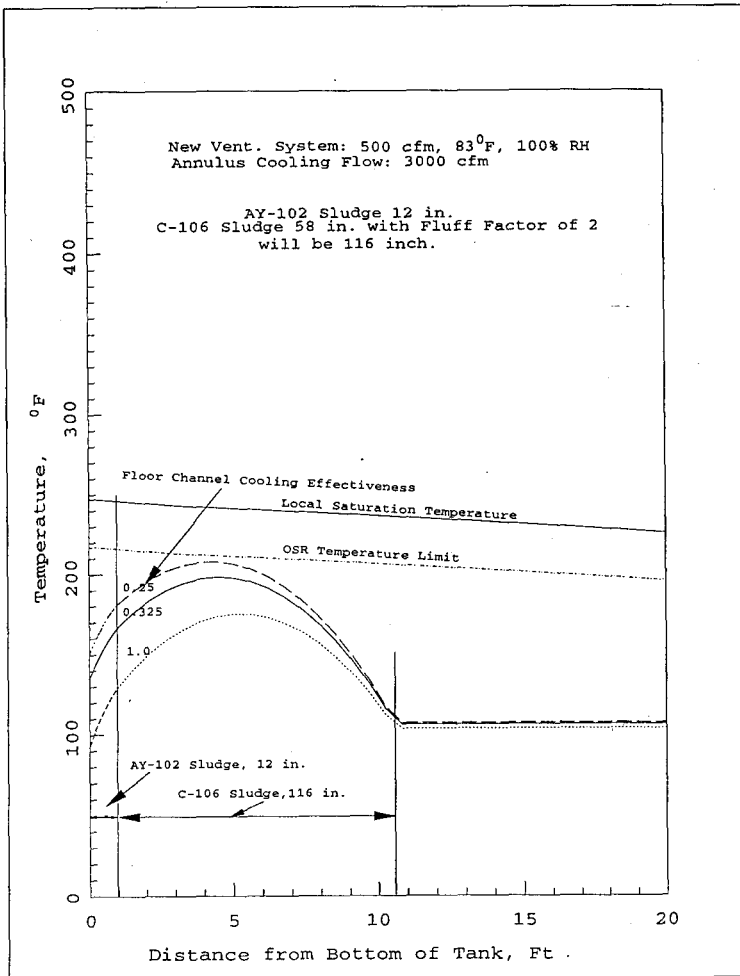


Figure 7. Temperature Distribution for the Combined Sludge of AY-102 and C-106 Using 500 cfm Primary and 2000 cfm Annulus Ventilation Flow.

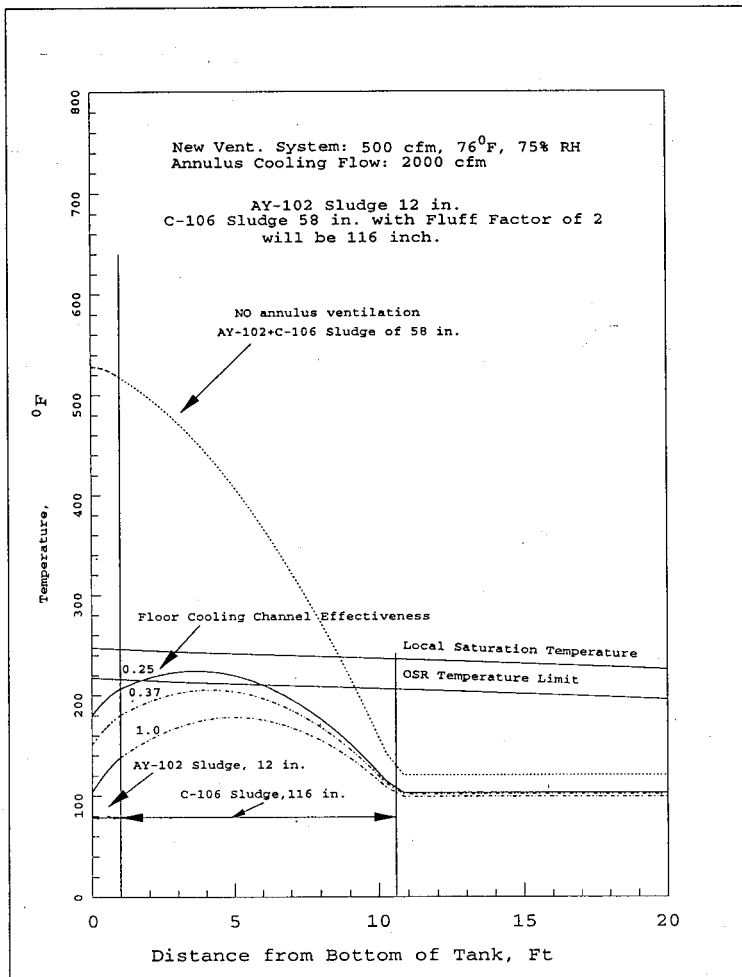


Figure 8. Temperature Distribution for the Combined Sludge of AY-102 and C-106 Using 500 cfm Primary and 2500 cfm Annulus Ventilation Flow.

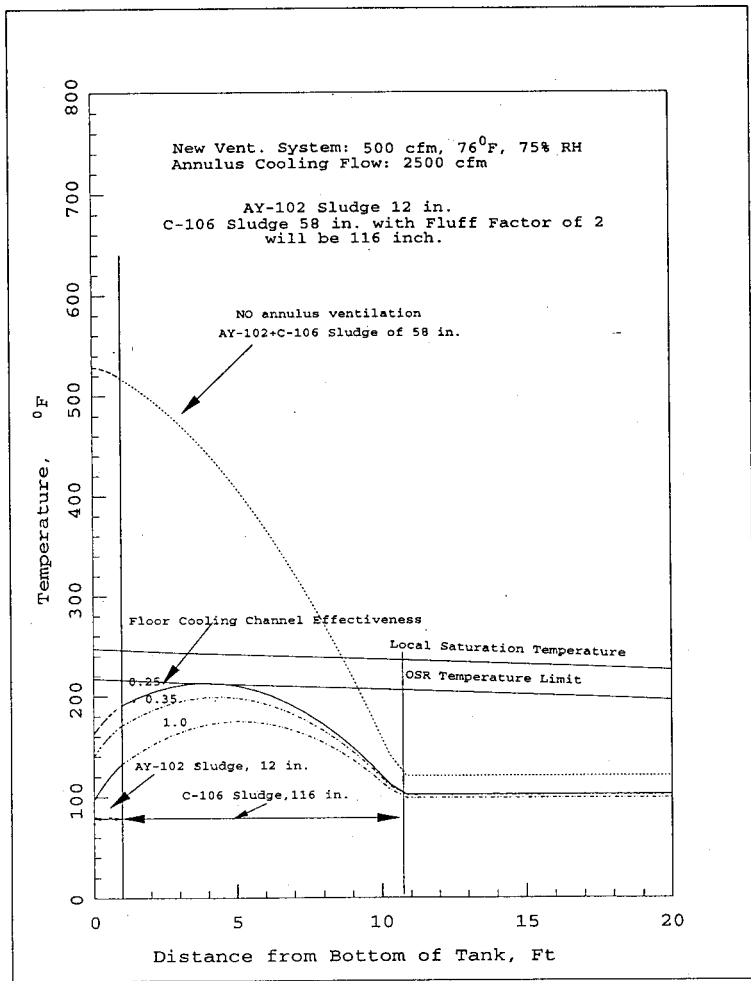
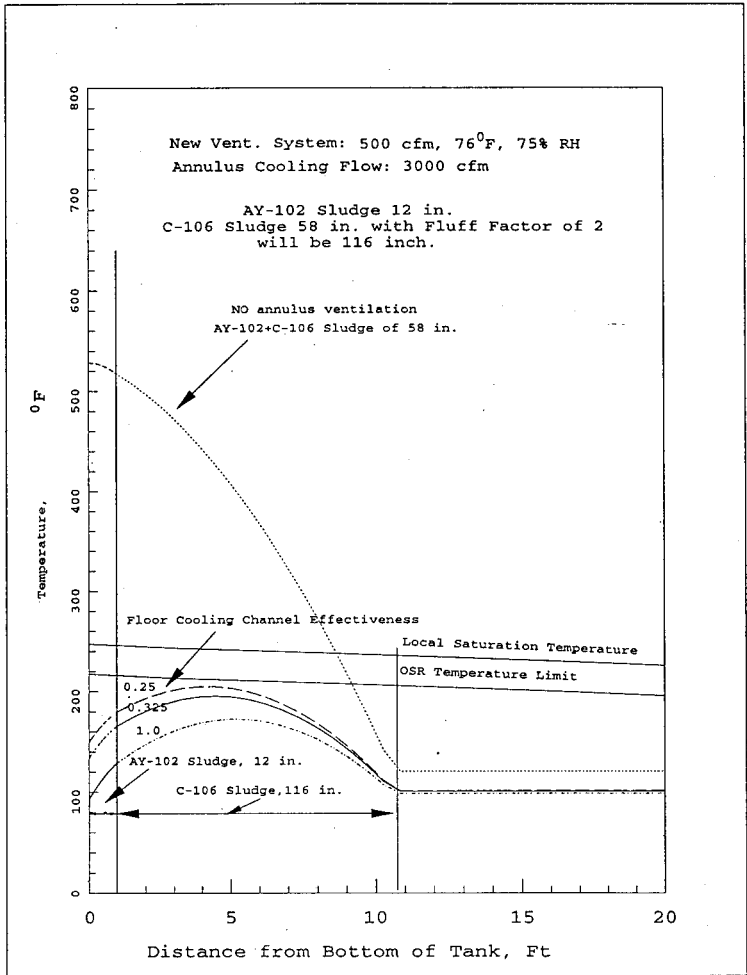


Figure 9. Temperature Distribution for the Combined Sludge of AY-102 and C-106 Using 500 cfm Primary and 3000 cfm Annulus Ventilation Flow.



Westinghouse
Hanford CompanyInternal
Memo

From: Double-Shell Tank Safety Analysis 29140-94-001
 Phone: 376-2613 H4-63
 Date: January 11, 1994
 Subject: SAFETY CLASSIFICATION OF THE STANDARD HYDROGEN MONITORING SYSTEM
 FOR FLAMMABLE GAS WATCH LIST TANKS

To: R. E. Clayton S1-54

cc: K. O. Fein	H4-63	R. J. Kidder	H4-61
K. D. Gibson	H4-61	D. T. Lott	R3-49
J. M. Grigsby	H4-62	R. W. Reed	R1-51
J. A. Hurley	R3-49	T. C. Schneider	L7-04
M. N. Islam	R3-08	M. H. Shannon	H4-61
RJVJ File/LB			

This letter provides the safety classification of the standard hydrogen monitoring system. This is a piece of monitoring equipment to be installed on both single-shell and double-shell flammable gas watch list tanks.

To date, a controversy exists for safety classification of monitoring equipment. It is well recognized that the failure of the equipment itself usually does not create an immediate consequence. However, if the failed monitoring equipment is not fixed, potential changes in the tank (waste level, temperature, or in this case flammable gas generation) could lead to an unsafe condition that potentially could cause a safety class 2 or possibly safety class 1 consequence to occur. This issue is currently under negotiation with the U.S. Department of Energy.

The first standard hydrogen monitoring systems were installed on Tank 241-SY-101 (101-SY). The safety basis documentation for this is contained in the following places.

WHC-SD-WM-SAD-003, Rev. 3, *Safety Assessment for Window B Activities in Tank 101-SY*, describes installation of probe assemblies into the tank (these will be used for single-shell tanks) and installation of instrumentation in the exhaust header (the approach to be used for double-shell tanks).

~~WHC-SD-WM-SAD-007~~, Rev. 1, *Safety Assessment for Operation of the Temporary Gas Monitoring System in Tank 101-SY*, describes the components used to make up the temporary gas monitoring system. The same or similar components were used to make the standard hydrogen monitoring system.

External letter 9255759, "Safety Documentation for Non-Pump Work in Tank 241-SY-101, Window G," from D. C. Richardson to R. E. Gerton, dated July 31, 1993, contained an attachment entitled

R. E. Clayton
Page 2
January 11, 1994

29140-94-001

removal of the standard hydrogen monitoring system. The U.S. Department of Energy (both HQ and RL) authorized installation for Tank 101-SY.

External letter 9308225B R1, "PLANNED WORK ACTIVITIES FOR TANK 241-SY-103," from H. D. Harmon to J. H. Anttonen, dated November 24, 1993, contained an attachment entitled "Basis for Installation, Operation, and Repair of Standard Hydrogen Monitoring Systems in the SY Tank Farm." The U.S. Department of Energy, Richland Field Office, authorized the installation for Tank 103-SY.

The standard hydrogen monitoring systems to be installed on the other flammable gas watch list tanks present no new hazards that have not already been analyzed in the above mentioned document. All components of the system meet the specifications of the National Fire Protection Association National Electric Code for use in Class 1, Division 1, Group B (hydrogen) atmospheres. No credible accident initiating events were determined to exist in the above documentation. The drilling of the sample hole and the return hole in the ventilation system was also analyzed. In fact, it was determined by a laboratory demonstration that the autoignition temperature for hydrogen could not be reached during the drilling operation.

If the standard hydrogen monitoring system failed, flammable gases accumulated in concentrations that could be ignited, and an ignition source was introduced, a fire/deflagration could occur in the tank. This is a highly unlikely situation since all tanks are ventilated (active or passive), the tanks on the flammable gas watch list require a sampling of the tank vapor space to ensure that concentrations are below 25 % of the lower flammable limit before and during any activity in the dome space and/or ventilation system and measures are taken to eliminate spark sources (e.g., electrical grounding and bonding, spark resistant tools and materials, and slow and deliberate insertion or removal of equipment).

However, the consequences of an ignition of a large quantity of flammable gas have been calculated for Tank 101-SY. This calculation assumed that a 34.3 cm (13.5 inch) level drop occurred and when the peak hydrogen concentration was reached, an ignition source was introduced. This resulted in a fire/deflagration with an associated pressure pulse. The pressure pulse propagated through the ventilation system and blew out the HEPA filters. The HEPA filters were at their maximum loading. There was also material picked up from the waste surface that was entrained in the gases leaving the tank. The onsite receptor received an effective dose equivalent of 3.9 mSv (0.39 rem) and the offsite receptor received an effective dose equivalent of 1.05 mSv (0.105 rem). The majority of the dose consequence is due to the filter loading. Therefore, even if other tanks have entrained material from the waste surface that contributes more to the dose consequences, they will not change significantly. Thus, these consequences are representative of consequences on other tanks.

These consequences do not support the classification of the standard hydrogen monitoring system as safety class 1 or safety class 2. None of the

R. E. Clayton
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other criteria for safety class 1 or 2 (see MRP 5.46) are satisfied either. It is felt that the failure of the standard hydrogen monitoring system could preclude the implementation of the as low as reasonably achievable principals for exposure to radioactive or nonradiological hazardous materials.

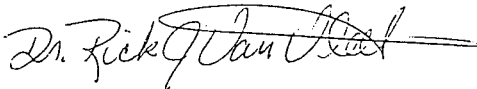
The following table presents the various components of the standard hydrogen monitoring system and gives their safety classification.

Table 1. Safety Classification of Standard Hydrogen Monitoring System

System, Item, or Component	Safety Class
Standard Hydrogen Monitoring System	3
• concrete pad	4
• tubing	3
• heat tracing	3
• saddle clamp (DSTs) ^a	3
• water jacketed probe assemblies (SSTs)	3
• electric tie-ins	3
• environmentally controlled instrumentation cabinet	3
• gas rack and bottles	3

^a Note that the exhaust header is safety class 2 while the SHMS is safety class 3.

If you have any questions, please feel free to contact me on 376-2613 or via cc:Mail. Thank you very much.



R. J. Van Vleet, Ph.D.
Principal Engineer
Double-Shell Tank Safety Analysis

gjr

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DISTRIBUTION SHEET

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Repository of Not Readily Available Documents for Project W-320 /E09120		ECN No. N/A

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SE Chalk	A2-25				X
JC Conner	A2-25	X			
SK Farnsworth	H5-57				X
GW Gault	R1-44				X
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