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Radiological and Toxicological Consequences of a Worst-Case Spray Leak Related To Project W-320

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Abstract: An analysis was performed of radiological and toxicological consequences of a worst-case leak from a 2-inch diameter flush connection in a pit over tank AY-102. The unmitigated (without controls) flush line spray leak assumes that the blank connector and the removable plug in the pit cover block have been removed so that the maximum system flow is directed out of the open 2-inch line vertically into the air above the pit. The mitigated (with controls) spray scenario assumes the removable plug is in place and the flow is directed against the underside of the pit cover block. The unmitigated scenario exceeded both onsite and offsite risk guidelines for an anticipated accident. For the mitigated case all consequences are well within guidelines and so no additional controls are needed beyond the existing control of having all pit covers and removable plugs in place during any waste transfer.

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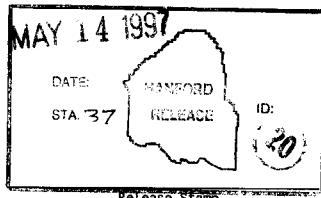
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RADIOLOGICAL AND TOXICOLOGICAL CONSEQUENCES OF A
WORST-CASE SPRAY LEAK RELATED TO PROJECT W-320

D.A. Himes
3/31/97

During sluicing operations in Tank 241-C-106, supernate liquid from Tank 241-AY-102 and slurry of varying composition from C-106 will be pumped under pressure between the two tanks. During the operation, should containment barriers breach somewhere along the transfer route, a pressurized spray release to the environment could occur. Pressurized spray releases are of safety concern because they can be relatively efficient generators of respirable sized aerosols. Spray releases can result from small holes or cracks in transfer piping, improperly installed transfer jumpers, or defective or degraded seals or gaskets on pumps and valves. Mechanisms such as aging, corrosion, erosion, water hammer, overpressure, freezing, mechanical fatigue, thermal stresses, construction flaws, and human error can lead to these failures. Spray leaks can also occur due to misroutes through compromised piping or jumpers. Spray leaks such as these are bounded by those already analyzed in the existing TWRS safety documentation. Radiological and toxicological consequences of spray leak accidents in Hanford liquid waste tank farm pits were previously estimated and reported in WHC-SD-WM-CN-048 Rev 1, *Calculation Notes in Support of TWRS FSAR Spray Leak Accident Analysis* (Hall 1996) in support of the Tank Waste Remediation System (TWRS) Final Safety Analysis Report (FSAR), and further analyzed in HNF-SD-WM-CN-096 Rev 0, *Refined Radiological and Toxicological Consequences of Bounding Spray Leak Accidents in Tank Farm Waste Transfer Pits* (Himes 1997).

The only such accident related to Project W-320 which has not been previously considered is associated with the sluice line and slurry line flush connections located in pits over tank AY-102 (the highest elevation in the system). These connections are 2-inch (nominal) diameter pipes directed vertically upward under removable plugs in the pit cover blocks. The flush connections are normally closed by blanked jumper-type connectors. The unmitigated (without controls) flush line spray leak assumes that the blank connector and the removable plug in the pit cover block have been removed so that the maximum system flow is directed out of the open 2-inch line vertically into the air above the pit. The mitigated (with controls) spray scenario assumes the removable plug is in place and the flow is directed against the underside of the pit cover block. Previous analysis (attachment 1) has shown that maximum flow from the connection is not sufficient to lift the 350 lb removable plug. These scenarios were analyzed for both the sluice line (high flow rate, low solids content) and the slurry return line (lower flow, high solids content) to determine worst-case radiological and toxicological consequences.

Spray Leak Scenarios:

Two bounding accident scenarios have been chosen to represent the range of flush connector spray leaks which could occur in the sluice and pump pits over Tank 241-AY-102.

==> An unmitigated release of waste issuing from a flush connection over AY-102. The pit cover plug over the flush connection was assumed to be removed and the stream to be directed vertically upward. Both a slurry line release from the 241-AY-02A pump pit and a sluice line release from the 241-AY-02E sluice pit were evaluated to determine the worst case. Both flush connections are nominal 2 inch schedule 40 pipe with an inside diameter of 2.067 inches. In the case of the sluice line, the pump is very close to the open flush connection and will run at maximum speed (3,056 rpm) assuming no discharge head. The maximum flow rate under these conditions is 650 gpm (41.0 L/s) with a discharge velocity at the flush connection of 65.3 ft/s (19.9 m/s) (see attachment 2).

In the case of the slurry line returning from C-106, the flush connection is at an elevation 35 ft higher than the slurry pump and the material must traverse about 2000 ft of pipe run. The flush connection is, in fact, very close to, but at a higher elevation, than the slurry distribution nozzles in AY-102. The flow from the flush connection would therefore be expected to be about the same as the normal 350 gpm flow rate for the slurry line. For this analysis, however, the flow was conservatively assumed to be 450 gpm (28.4 L/s), or about 100 gpm above the expected flow rate. The corresponding flow velocity from the flush connection was estimated to be 45.2 ft/s (13.8 m/s). Consistent with previous spray release analyses in the TWRS safety documentation, the flush connection release was assumed to continue unabated for 24 hours.

==> A mitigated release of waste issuing from a flush connection over AY-102. The conditions are the same as assumed above except the removable plug in the pit cover block over the flush connection was assumed to be in place. As before, both a slurry line release within the 241-AY-02A pump pit and a sluice line release within the 241-AY-02E sluice pit were evaluated to determine the worst case. The impact of the stream on the underside of the pit cover was assumed to saturate the air within the pit to the maximum sustainable air loading of 100 mg/m^3 (ANSI N46.1 1980). The direct aerosol release is then carried with the air displaced from the pit while it fills with slurry. Note that the total amount of air displaced from the pit is 35% more than the volume of the pit due to an initial expansion of the air due to an assumed increase in air temperature and relative humidity from 30°F at 15% R.H. to 120°F at 100% R.H. (Hall 1996). After the pit fills the spray release would end and the slurry would spread over the ground above the pit as a pool. The analysis of pool releases is the subject of another document and is outside the scope of this analysis.

Both the AY-02A and AY-02E pits are equipped with 6-inch high capacity drains emptying directly into tank AY-102 (see Attachment 2). These drains are designed to handle the maximum flow from an open transfer line. In addition, both pits are equipped with leak detectors which would alarm before the liquid reached the levels of the high capacity drains. For purposes of this bounding analysis, the high capacity drains were assumed to be blocked and no credit was taken for the leak detectors. Since a negative pressure is maintained in the pits via the drains to AY-102, the consequences with the drains working would be far less severe.

Atmospheric Transport:

Receptor locations and atmospheric dispersion factors (X/Q') were developed and are reported in WHC-SD-WM-SARR-016, *Tank Waste Compositions and Atmospheric Dispersion Coefficients for Use in Safety Analysis Consequence Assessments* (Van Keuren 1996a). For short duration ground level releases the < 1 hour X/Qs were used. The reported values are X/Q' = 3.41E-2 s/m^3 for the onsite receptor (at 100 m) and X/Q' = 2.83E-5 s/m^3 for the offsite receptor (at the site boundary or the near bank of the Columbia River, whichever is closer). Exposures of the onsite and site boundary were calculated using 12-hour and 24-hour X/Qs, respectively. For release durations intermediate between 2 hours and 1 year (8760 h), the standard logarithmic averaging formulation was used where the X/Q' over a release time of x hours is given by:

$$\ln\left(\frac{X}{Q'}\right)_x = \left[\ln\left(\frac{X}{Q'}\right)_{1y} - \ln\left(\frac{X}{Q'}\right)_{2h}\right]\left[\frac{\ln(x) - \ln(2)}{\ln(8760) - \ln(2)}\right] + \ln\left(\frac{X}{Q'}\right)_{2h}$$

where it is assumed that the release rate is reasonably constant over the time x hours. The resulting X/Qs are shown in Table 1.

Table 1: Atmospheric dispersion coefficients (X/Q')

Receptor	Release Duration	X/Q' (s/m^3)
Onsite	< 1 hr	3.41E-2
	2 hr	1.13E-2
	12 hr	5.54E-3
	1 y	4.03E-4

Receptor	Release Duration	X/Q' (s/m^3)
Offsite	< 1 hr	2.83E-5
	2 hr	2.12E-5
	24 hr	4.62E-6
	1 y	1.24E-7

Note that the X/Q' decreases rapidly as receptor distance increases, and also decreases with increasing averaging time (i.e., release duration at a constant rate). A given release will therefore produce more severe consequences if released over a shorter time than if released over a longer time.

Calculations of toxicological consequences for releases considered here assume a continuous release (as opposed to a puff). The appropriate X/Qs are built into the unit release rate sums of fractions (SOF) developed in WHC-SD-WM-SARR-011, *Toxic Chemical Considerations for Tank Farm Releases* (Van Keuren 1996b) and do not need to be handled explicitly here.

Consequence Methodology:

Radiological and toxicological consequences of releases from the 200 Area Tank Farms were calculated using radiological dose and toxic exposure conversion factors developed in WHC-SD-WM-SARR-037, *Development of Radiological Concentrations and Unit Liter Doses for TWRS FSAR Radiological Consequence Calculations* (Cowley 1996) and WHC-SD-WM-SARR-011, *Toxic Chemical Considerations for Tank Farm Releases* (Van Keuren 1996b). Unit Liter Doses (ULD) for Tanks 241-C-106 and 241-AY-102 solids and liquids are shown in Table 2. These ULDs were taken from WHC-SD-WM-SARR-037 for SST and AWF waste, respectively.

Table 2:   Unit Liter Doses (ULD) for Tanks 241-C-106
and 241-AY-102 waste components

Waste Component		Inhalation ULD (Sv/L)	Ingestion ULD (Sv·m^3/s·L)
Tank 241-C-106	Liquids	1.1E+4	5.2E-2
	Solids	2.2E+5	4.1E+0
Tank 241-AY-102	Liquids	1.4E+3	9.2E-2
	Solids	1.7E+6	8.1E+0

Based on the total amounts of solids and liquids in the two tanks, the compositions of the solid and liquid components of the slurry circulating in both directions between tanks C-106 and AY-102 in the sluice line and slurry line have been determined to have the following best estimate compositions:

Liquids => 10% SST liquids + 90% AWF liquids

Solids => 90% SST solids + 10% AWF solids

The resulting ULDs for the slurry circulating between the two tanks are shown in Table 3.

Table 3: Unit Liter Doses (ULD) for solid and
liquid components of circulating slurry

Slurry Component	Inhalation ULD (Sv/L)	Ingestion ULD $(Sv \cdot m^3/s \cdot L)$
Liquids	2.36E+3	8.80E-2
Solids	3.68E+5	4.50E+0

The sluice supernate being pumped from AY-102 to C-106 was assumed to be composed of 10% solids and 90% liquids, while the slurry being pumped back from C-106 was assumed to be composed of 33% solids and 67% liquids. The resulting ULDs for the two lines between C-106 and AY-102 are shown in Table 4.

Table 4: Unit Liter Doses (ULD) for sluice supernate
from AY-102 and slurry from C-106

Transfer Line	Inhalation ULD (Sv/L)	Ingestion ULD $(Sv \cdot m^3/s \cdot L)$
Sluice Line from AY-102	3.89E+4	5.29E-1
Slurry Line from C-106	1.23E+5	1.54E+0

These ULDs were used to calculate onsite and offsite receptor radiological doses using the following formulas. All doses are 50-year committed effective dose equivalents (CEDE). Ingestion doses are for a 24-hour uptake period by the offsite receptor immediately after the passage of the plume assuming a 24 hour delay before evacuation and/or interdiction of food supplies.

For onsite and offsite inhalation doses:

$$D_{inh} = (Q)(X/Q')(BR)(ULD_{inh})$$

And for offsite ingestion doses:

$$D_{ing} = (Q)(X/Q')(ULD_{ing})$$

Where

D_{inh} = inhalation dose (Sv)
D_{ing} = ingestion dose (Sv)
Q = respirable release in terms of liters of waste material (L)
X/Q' = atmospheric dispersion coefficient (s/m^3)
BR = receptor breathing rate (m^3/s)
ULD_{inh} = inhalation unit liter dose (Sv/L)
ULD_{ing} = ingestion unit liter dose (Sv·m^3/s·L)

For short-duration releases and for 12-hour exposures to the onsite receptor, the light activity breathing rate of 3.3E-4 m^3/s was assumed. For 24-hour release exposures to the offsite receptor, the 24 hour average breathing rate of 2.7E-4 m^3/s was assumed.

Toxicological exposure units were developed in WHC-SD-WM-SARR-011 in terms of a sum-of-fractions per unit release rate (L/s), or per unit release (L) for very short duration (puff) releases. Puff releases are defined in WHC-SD-WM-SARR-011 as being releases with durations $\leq$3.5 s for the onsite receptor or $\leq$250 s for the site boundary receptor. This parameter already contains the receptor X/Q' (1 h or puff) and the chemical component limits associated with a particular accident frequency. The frequency for the spray leak scenarios considered here has been designated as anticipated with a frequency range of 1 - 10^{-2}/y. Unit release rate sums of fractions for SST and AWF waste given in WHC-SD-WM-SARR-011 for continuous releases are shown in Table 5.

Table 5: Unit release toxicological sums of fractions for SST or AWF waste components for anticipated accident frequency (1 - 10^{-2}/y)

Receptor	Waste Component		Sum of Fractions (s/L)
Onsite	Single-Shell	Liquids	9.6E+3
		Solids	4.0E+4
Offsite	Single-Shell	Liquids	8.0E+0
		Solids	9.4E+1

Receptor	Waste Component		Sum of Fractions (s/L)
Onsite	Double-Shell or AWF	Liquids Solids	1.0E+4 1.8E+4
Offsite	Double-Shell or AWF	Liquids Solids	8.4E+0 1.9E+2

Given the same solid and liquid component compositions as before, the resulting continuous release SOFs for the slurry circulating between the two tanks are shown in Table 6.

Table 6:   Unit release toxicological sums of fractions for liquid and solid slurry components for anticipated accident frequency $(1 - 10^{-2}/y)$

Receptor	Slurry Component	Sum of Fractions (s/L)
Onsite	Liquids Solids	9.96E+3 3.78E+4
Offsite	Liquids Solids	8.36E+0 1.04E+2

The resulting continuous release ULDs for the two lines between C-106 and AY-102 are shown in Table 7.

Table 7:   Unit release toxicological sums of fractions for sluice supernate from AY-102 and slurry from C-106 for anticipated accident frequency

Transfer Line	Receptor	Sum of Fractions (s/L)
Sluice Line from AY-102	Onsite Offsite	1.27+4 1.79+1
Slurry Line from C-106	Onsite Offsite	1.91E+4 3.99E+1

Unmitigated Release Results:

In this case the removable plug over the flush connection has been removed from the pit cover block allowing unimpeded flow vertically into the air. Two sources of aerosolization were evaluated: (1) direct production by edge shear as the slurry flows out of the nozzle and (2) instability/shear stress at the surface of the liquid during the fall from its maximum height and impact on the ground (assumed to be a hard surface). The passage of the falling material through the air creates airflow patterns and turbulence that aids in suspension of the slurry. Both the sluice supernate and slurry return flows were investigated to determine the worst case.

The details of the nozzle spray were modelled using the SPRAY code (Hey and Leach 1994). For the unmitigated case, the orifice was assumed to be a round-edged circular hole with a diameter of 2.067 inches. Note that large leaks with high volume flow rates are less efficient generators of respirable aerosol (i.e., lower respirable fraction), but because of the high flow rate, the total respirable aerosol generation rate tends to have a relatively weak dependence on the size of the leak for large leaks. This type of slurry is a non-Newtonian fluid which could have a viscosity of about 20 cps for shear rates encountered during normal flow in pipes during a transfer. For the high shear rates present in aerosol producing processes, however, a viscosity of 1 cps was assumed consistent with WHC-SD-WM-CN-048. Densities for the solid and liquid components of the circulating slurry were assumed to be 1.82 g/cm^3 and 1.21 g/cm^3, respectively (Sathyanarayana 1996). The sluice supernate from tank AY-102 (10% solids) will then have a density of 1.27 g/cm^3 while the slurry from tank C-106 (33% solids) will have a density of 1.41 g/cm^3.

Care must be taken to correct for evaporation when defining the respirable size fraction of the spray release at the nozzle. A water droplet with an initial diameter D_i and a volumetric dissolved or suspended solids fraction E will, after evaporation of the water, form a solid particle with a final diameter D_f approximately related to D_i by $D_i = (D_f^3/E)^{1/3}$ (Hey and Leach 1994). The maximum respirable particle size is normally taken to be 10 μm. This size particle has a gravitational fall velocity (approximately 1 cm/s) about equal to the velocity associated with random vorticity in air. This is, therefore, also about the maximum size particulate which can be transported any distance from a ground level source under low wind speed conditions. For $D_f = 10$ μm and E = 0.33, D_i is 14.5 μm. The respirable fraction of the nozzle spray for the slurry from tank C-106 (33% solids) is therefore the fraction of aerosol particles with size less than or equal to 14.5 μm. Similarly, the respirable fraction of the nozzle spray for sluice supernate (10% solids) was based on a maximum diameter of 21.5 μm.

Parametric analyses were performed using the SPRAY Code (version 3.0, May 3, 1994) (Hey and Leach 1994) to determine upstream pressures within the pipe which matched the estimated liquid velocities at the nozzle and hence the corresponding respirable release rates. The SPRAY code run files for the

cases matching the nozzle exit velocities are shown in Attachment 3. The
results are shown in Table 8.

Table 8: Respirable nozzle spray releases for the
sluice supernate and slurry return lines

Transfer Line	Nozzle Diff. Pressure (psig)	Release Rate (L/s)	12 Hour Release (L)	24 Hour Release (L)
Sluice Line	38.0	1.74E-7	7.52E-3	1.50E-2
Slurry Line	20.5	2.08E-8	8.99E-4	1.80E-3

These direct spray releases from the nozzle were negligible compared to the
respirable releases produced by the fall and impact of the stream after
reaching maximum height above the pit cover. The releases due to the fall and
impact will now be treated in detail and the consequences calculated for each
of the two slurry types.

==> sluice line spray:

The respirable aerosol release produced by the fall and impact of the liquid
stream was calculated using methodology recommended in section 3.2.3.1 of DOE-
HDBK-3010-94 (DOE 1994). Neglecting effects of air resistance, a liquid
stream directed vertically upward will attain a height, h, given by

$$h = \frac{1}{2} \frac{v^2}{g}$$

where v is the initial upward velocity and g is the acceleration due to
gravity (32.2 ft/s^2). A vertical stream with an initial velocity of 65.3 ft/s
can then reach a height of 66.2 ft or 2.02E+3 cm. The airborne release
fraction (ARF) of a liquid or slurry falling and impacting on a hard surface
from a height h is given by

$$ARF = 8.9E\text{-}10 \, Arch^{0.55}$$

Arch is the Archimedes Number given by

$$Arch = \frac{\rho^2 h^3 g}{\mu^2}$$

where ρ is the density of air (1.293E-3 g/cm^3), h is the release height (cm), g is the acceleration due to gravity (981 cm/s^2), and μ is the liquid viscosity (1 E-2 poise). The Archimedes Number for this case is then 1.35E+11 leading to an airborne release fraction of 1.18E-3. As recommended in DOE-HDBK-3010-94 for this type of release, the respirable fraction (RF) was assumed to be 1. The resulting respirable release rate is (41.0 L/s)(1.18E-3) = 4.84E-2 L/s. The corresponding 12-hour and 24-hour respirable releases are 2.09E+3 L and 4.18E+3 L, respectively.

The onsite receptor inhalation dose was calculated using the 12-hour release and X/Q' (from Table 1) as follows. ULDs were taken from Table 4.

D_{inh} = (R)(X/Q')(BR)(ULD)
   = (2.09E+3 L)(5.54E-3 s/m^3)(3.3E-4 m^3/s)(3.89E+4 Sv/L)
   = 1.49E+2 Sv (1.49E+4 rem)

The offsite dose is the sum of the 24-hour inhalation and ingestion doses as follows. Note that the 24 hour average breathing rate was used for the inhalation dose.

D_{inh} = (R)(X/Q')(BR)(ULD)
   = (4.18E+3 L)(4.62E-6 s/m^3)(2.7E-4 m^3/s)(3.89E+4 Sv/L)
   = 2.03E-1 Sv

D_{ing} = (R)(X/Q')(BR)(ULD)
   = (4.18E+3 L)(4.62E-6 s/m^3)(5.29E-1 Sv·m^3/s·L)
   = 1.02E-2 Sv

Total offsite dose = 2.13E-1 Sv (2.13E+1 rem)

Toxicological Sums of Fractions (SOF) were obtained by multiplying the release rate by the unit release rate SOF from Table 7 as follows.

Onsite SOF = (4.84E-2 L/s)(1.27E+4 s/L)
         = 6.15E+2

Offsite SOF = (4.84E-2 L/s)(1.79E+1 s/L)
         = 8.66E-1

==> slurry line spray:

A vertical stream with an initial velocity of 45.2 ft/s can then reach a height of 31.7 ft or 9.67E+2 cm. The Archimedes Number for this case is then 1.48E+10 leading to an airborne release fraction of 3.49E-4. As recommended in DOE-HDBK-3010-94 for this type of release, the respirable fraction (RF) was assumed to be 1. The resulting respirable release rate is (28.4 L/s)(3.49E-4) = 9.92E-3 L/s. The corresponding 12-hour and 24-hour respirable releases are 4.28E+2 L and 8.57E+2 L, respectively.

The onsite receptor inhalation dose was calculated using the 12-hour release and X/Q' (from Table 1) as follows. ULDs were taken from Table 4.

$$D_{inh} = (R)(X/Q')(BR)(ULD)$$
$$= (4.28E+2\ L)(5.54E-3\ s/m^3)(3.3E-4\ m^3/s)(1.23E+5\ Sv/L)$$
$$= 9.62E+1\ Sv\ (9.62E+3\ rem)$$

The offsite dose is the sum of the 24-hour inhalation and ingestion doses as follows. Note that the 24 hour average breathing rate was used for the inhalation dose.

$$D_{inh} = (R)(X/Q')(BR)(ULD)$$
$$= (8.57E+2\ L)(4.62E-6\ s/m^3)(2.7E-4\ m^3/s)(1.23E+5\ Sv/L)$$
$$= 1.31E-1\ Sv$$

$$D_{ing} = (R)(X/Q')(BR)(ULD)$$
$$= (8.57E+2\ L)(4.62E-6\ s/m^3)(1.54E+0\ Sv \cdot m^3/s \cdot L)$$
$$= 6.10E-3\ Sv$$

Total offsite dose = 1.38E-1 Sv (1.38E+1 rem)

Toxicological Sums of Fractions (SOF) were obtained by multiplying the release rate by the unit release rate SOF from Table 7 as follows.

Onsite SOF = (9.92E-3 L/s)(1.91E+4 s/L)
            = 1.89E+2

Offsite SOF = (9.92E-3 L/s)(3.99E+1 s/L)
            = 3.96E-1

Mitigated Release Results:

In this case the removable plug over the flush connection remains in place confining the slurry stream from the flush connection to the pit. This is the only change from the unmitigated release case. It was assumed (consistent

with WHC-SD-WM-CN-048) that the impact of the stream on the underside of the pit cover saturates the air within the pit to the maximum sustainable air loading of 100 mg/m^3 (ANSI N46.1 1980). The direct aerosol release is then carried with the air displaced from the pit while it fills with slurry. No credit is taken in this bounding analysis for either the leak detectors or the 6-inch high capacity drains in the pits. This direct release will now be evaluated in detail for the two slurry types. Note that once the pit fills and overflows, the slurry will form a pool on the ground above. The releases from such a pool are beyond the scope of this analysis and will be treated elsewhere.

==> sluice line spray:

The sluice line flush connection is in pit 241-AY-02E with inside dimensions of 8 ft x 6 ft x 7 ft (see Attachment 2) giving an interior volume of 336 ft^3 or 9.5 m^3. The total volume displaced while the pit is filling with slurry is this volume plus an additional 35% due to heating of the air in the pit and addition of water vapor up to 100% R.H. (Hall 1996). The total air volume displaced out of the pit through crevices and small openings is then 12.8 m^3 implying a slurry aerosol release of 1.28 g. Using the sluice supernate density, the equivalent slurry volume can be calculated as (1.28 g)/(1.27 g/cm^3) = 1.01 cm^3 or 1.01E-3 L. At a slurry addition rate of 41.0 L/s or 4.10E-2 m^3/s, the pit will fill in 232 s or 3.86 minutes. Note that no credit was taken for volume taken up by piping and machinery within the pit. The slurry aerosol release rate due to volume displacement is then (1.01E-3 L)/(232 s) = 4.35E-6 L/s.

The onsite receptor inhalation dose was calculated using the < 1-hour release and X/Q' (from Table 1) as follows. ULDs were taken from Table 4.

$$D_{inh} = (R)(X/Q')(BR)(ULD)$$
$$= (1.01E-3 \ L)(3.41E-2 \ s/m^3)(3.3E-4 \ m^3/s)(3.89E+4 \ Sv/L)$$
$$= 4.42E-4 \ Sv \ (4.42E-2 \ rem)$$

The offsite dose is the sum of the inhalation and ingestion doses as follows. Note that the < 1-hour X/Q' and the light activity breathing rate was used due to the short release duration.

$$D_{inh} = (R)(X/Q')(BR)(ULD)$$
$$= (1.01E-3 \ L)(2.83E-5 \ s/m^3)(3.3E-4 \ m^3/s)(3.89E+4 \ Sv/L)$$
$$= 3.67E-7 \ Sv$$

$$D_{ing} = (R)(X/Q')(BR)(ULD)$$
$$= (1.01E-3 \ L)(2.83E-5 \ s/m^3)(5.29E-1 \ Sv \cdot m^3/s \cdot L)$$
$$= 1.51E-8 \ Sv$$

Total offsite dose = 3.82E-7 Sv (3.82E-5 rem)

Toxicological Sums of Fractions (SOF) were obtained by multiplying the release rate by the unit release rate SOF from Table 7 as follows.

$$\text{Onsite SOF} = (4.35\text{E-}6 \text{ L/s})(1.27\text{E+}4 \text{ s/L})$$
$$= 5.53\text{E-}2$$

$$\text{Offsite SOF} = (4.35\text{E-}6 \text{ L/s})(1.79\text{E+}1 \text{ s/L})$$
$$= 7.79\text{E-}5$$

==> slurry line spray:

The slurry line flush connection is in pit 241-AY-02A with inside dimensions of 12 ft x 8 ft x 5 ft (see Attachment 2) giving an interior volume of 480 ft³ or 13.6 m³. The total volume displaced while the pit is filling with slurry is this volume plus an additional 35% due to heating of the air in the pit and addition of water vapor up to 100% R.H. (Hall 1996). The total air volume displaced out of the pit through crevices and small openings is then 18.4 m³ implying a slurry aerosol release of 1.84 g. Using the return slurry density, the equivalent slurry volume can be calculated as $(1.84 \text{ g})/(1.41 \text{ g/cm}^3) = 1.30$ cm³ or 1.30E-3 L. At a slurry addition rate of 28.4 L/s or 2.84E-2 m³/s, the pit will fill in 479 s or 7.98 minutes. Note that no credit was taken for volume taken up by piping and machinery within the pit. The slurry aerosol release rate due to volume displacement is then $(1.30\text{E-}3 \text{ L})/(479 \text{ s}) = 2.71\text{E-}6$ L/s.

The onsite receptor inhalation dose was calculated using the < 1-hour release and X/Q' (from Table 1) as follows. ULDs were taken from Table 4.

$$D_{inh} = (R)(X/Q')(BR)(ULD)$$
$$= (1.30\text{E-}3 \text{ L})(3.41\text{E-}2 \text{ s/m}^3)(3.3\text{E-}4 \text{ m}^3/\text{s})(1.23\text{E+}5 \text{ Sv/L})$$
$$= 1.80\text{E-}3 \text{ Sv } (1.80\text{E-}1 \text{ rem})$$

The offsite dose is the sum of the inhalation and ingestion doses as follows. Note that the < 1-hour X/Q' and the light activity breathing rate was used due to the short release duration.

$$D_{inh} = (R)(X/Q')(BR)(ULD)$$
$$= (1.30\text{E-}3 \text{ L})(2.83\text{E-}5 \text{ s/m}^3)(3.3\text{E-}4 \text{ m}^3/\text{s})(1.23\text{E+}5 \text{ Sv/L})$$
$$= 1.49\text{E-}6 \text{ Sv}$$

$$D_{ing} = (R)(X/Q')(BR)(ULD)$$
$$= (1.30\text{E-}3 \text{ L})(2.83\text{E-}5 \text{ s/m}^3)(1.54\text{E+}0 \text{ Sv·m}^3/\text{s·L})$$
$$= 5.67\text{E-}8 \text{ Sv}$$

Total offsite dose = 1.55E-6 Sv (1.55E-4 rem)

Toxicological Sums of Fractions (SOF) were obtained by multiplying the release rate by the unit release rate SOF from Table 7 as follows.

Onsite SOF = (2.71E-6 L/s)(1.91E+4 s/L)
            = 5.18E-2

Offsite SOF = (2.71E-6 L/s)(3.99E+1 s/L)
            = 1.08E-4

Conclusion:

The results of the two flush connection spray leak cases are summarized in Tables 9 through 12.

Table 9: Consequences of unmitigated sluice line spray

Hazard	Receptor	Dose/Exposure	Evaluation Guideline (anticipated)
Radiological	Offsite	210 mSv	1 mSv
	Onsite	150 Sv	5 mSv
Toxicological	Offsite	8.7E-1	1
	Onsite	6.2E+2	1

Table 10: Consequences of unmitigated slurry line spray

Hazard	Receptor	Dose/Exposure	Evaluation Guideline (anticipated)
Radiological	Offsite	140 mSv	1 mSv
	Onsite	96 Sv	5 mSv
Toxicological	Offsite	4.0E-1	1
	Onsite	1.9E+2	1

Between the unmitigated cases (cover block plug removed), the sluice line spray (Table 9) is more limiting due to the higher flow rate out of the flush connection and the greater height (and therefore fall distance) reached by the stream. This is due mainly to the proximity of the leak to the sluice pump.

Table 11: Consequences of mitigated sluice line spray

Hazard	Receptor	Dose/Exposure	Evaluation Guideline (anticipated)
Radiological	Offsite	0.00038 mSv	1 mSv
	Onsite	0.44 mSv	5 mSv
Toxicological	Offsite	7.8E-5	1
	Onsite	5.5E-2	1

Table 12: Consequences of mitigated slurry line spray

Hazard	Receptor	Dose/Exposure	Evaluation Guideline (anticipated)
Radiological	Offsite	0.0016 mSv	1 mSv
	Onsite	1.8 mSv	5 mSv
Toxicological	Offsite	1.1E-4	1
	Onsite	5.2E-2	1

Between the two mitigated cases (cover block plug in place), the slurry return line (Table 12) is more limiting due to higher solids content of the slurry and hence higher ULDs and unit release rate SOFs. For the mitigated case all consequences are well within guidelines and so no additional controls are needed beyond the existing control of having all pit covers and removable plugs in place during any waste transfer. The consequences shown in Table 12 do not include releases from the above-ground pool which would form once the pit fills with slurry. The analysis of such releases is beyond the scope of this document and are considered in a separate analysis.

In this analysis it is assumed that the slurry distributor above the sludge level in AY-102 is functioning so as to discharge the slurry in four horizontal directions as planned. If the slurry distributor were to come off the end of the slurry line from C-106, the effect (at least near the beginning of the operation) could be to mix a large amount of AY-102 slurry with the sluice liquid going to C-106. As a worst case, it could be assumed that the sluice liquid carries 33% AWF solids and 67% AWF liquids. This change would increase the ULDs and SOFs for the sluice liquid. The offsite toxicological SOF in Table 10 for the sluice line spray without controls would increase from 0.42 to about 1.6 which would not change any conclusions since the radiological dose is already above the guidelines. The onsite radiological dose for the mitigated sluice line spray shown in Table 11, however would

increase from 0.44 mSv to about 6.3 mSv. This would put the onsite consequences of the mitigated sluice line spray leak slightly above risk guideline of 5 mSv for an accident in the "anticipated" frequency class. All other consequences of the mitigated accident would remain below guidelines. (Note that it could be argued that the spray leak plus failure of the slurry distributor would be in the "unlikely" frequency category.)

Note that both pits are equipped with leak detectors and high capacity 6-inch drains for which no credit is claimed in this bounding analysis. Either one of these additional features would, in reality, reduce the consequences of the mitigated spray release to a small fraction of those shown in Table 12 , and, in addition, would prevent any overflow from the pit and formation of an above-ground pool.

References:

ANSI N46.1, 1980, *American National Standard - Guidance for Defining Safety-Related Features of Nuclear Fuel Cycle Facilities*, American Nuclear Society, La Grange Park, Illinois.

Cowley 1996, W.L. Cowley, *Development of Radiological Concentrations and Unit Liter Doses for TWRS FSAR Radiological Consequence Calculations*, WHC-SD-WM-SARR-037, April 1996.

DOE 1994, *DOE Handbook - Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities*, DOE-HDBK-3010-94, December 1994.

Hall 1996, B.W. Hall, *Calculation Notes in Support of TWRS FSAR Spray Leak Accident Analysis*, WHC-SD-WM-CN-048 Rev 1, September 1996.

Hey and Leach 1994, B.E. Hey and D.S. Leach, *A Model for Predicting Respirable Releases from Pressurized Leaks*, WHC-SD-GN-SWD-20007 Rev 0, April 1994.

Himes 1997, D.A. Himes, *Refined Radiological and Toxicological Consequences of Bounding Spray Leak Accidents in Tank Farm Waste Transfer Pits*, HNF-SD-WM-CN-096 Rev 0, February 1997.

Sathyanarayana 1996, K. Sathyanarayana, *Evaluation of Potential and Consequences of Steam Bump in High Heat Waste Tanks and Assessment and Validation of GOTH Computer Code*, WHC-SD-WM-CN-022 Rev 0, July 1996.

Van Keuren 1996a, J.C. Van Keuren, *Tank Waste Compositions and Atmospheric Dispersion Coefficients for use in Safety Analysis Consequence Assessments*, WHC-SD-WM-SARR-016 Rev 2, July 1996.

Van Keuren 1996b, J.C. Keuren, J.S. Davis, and M.L. Dentler, *Toxic Chemical Considerations for Tank Farm Releases*, WHC-SD-WM-SARR-011 Rev 2, July 1996.

Attachment 1
Analysis of Flushing Nozzle Lifting Force
by W-320 Design Staff

KAISER ENGINEERS
HANFORD

Calc. No. _W320-27-046_
Revision ___O___
Page No. ___1___ of ___2___

DESIGN ANALYSIS

Client _Numatec Hanford Corporation_   WO/Job No. _ED9147 / P2XY01_

Subject _Flushing Nozzle Lifting Force_   Date _3/11/97_   By _KK Peterson_
                                             Checked _3/24/97_ By _D.L. Evans_

Location _241-AY-102 02E Sluice Pit_   Revised   By

This calculation is to support USQ TF-97-0214 and ECN W320-587. The goal is to show a potential accident scenario, of not blanking off the flushing nozzle after flushing the sluice line, will not dislodge the cover block plug directly above the nozzle.

Assume that the velocity does not significantly change between the nozzle and just prior to striking the bottom of the plug. Also, assume that the fluid stream does not significantly widen in diameter from the nozzle exit to striking the bottom face of the plug. Assume the maximum flow rate from the inline pump is 680 gpm for the worst case. Assume worst case is for 10% solids with a specific gravity of 1.12. Assume all fluid is being pumped through the nozzle.

The calculation will use the formula for an open jet on a horizontal flat plate and comepare the resultant force with the weight of the cover block plug.

References:
  (1)   H-2-818454, Sheet 3, Detail 8
  (2)   H-2-918501, Sheet 1
  (3)   H-2-818503, Sheet 1
  (4)   HNF-SD-W320-FDC-001, Rev. 4, Sect. 2.2.2
  (5)   Vendor Data: Lawrence Pumps Inc, Vertical Inline, RPM 3056, Item P.1
  (6)   Lawrence Pumps Inc, Submersible/Slurry, RPM 1760, Item P-136.
  (7)   Mechanical Engineering Reference Manual, 8th ed., Michael Lindeburg, p. 3-29
  (8)   H-2-818544, Sheet 2

Conclusion:
  The force developed in the worst case situation (212 lb) is not sufficient to lift the cover block plug (350 lb).

☆ G.P.O.   689-996   12/9_

KAISER ENGINEERS
HANFORD

HNF-SD-WM-CN-102   Rev 0

Calc. No. _W320-27-046_
Revision ___0___
Page No. __2__ of __2__

DESIGN ANALYSIS

Client _Numatec Hanford Corporation_   WO/Job No. _E09147 / P2XY01_

Subject _Flushing Nozzle Lifting Force_   Date _3/11/97_   By _TK Peterson_

Checked _3/24/97_   By _D.L. Evans_

Location _241-AY-102 02E Sluice Pit_   Revised ___   By ___

Cover block plug weight = 350   Ref. 1

$Q = 680$ gpm , maximum   Ref. 5+6

Nozzle is 2" Ø schedule 40, 2¹⁄₁₆" ID   Ref. 2+3

specific gravity, $S_pG = 1.12$ for 10% solids   Ref. 4

16" from nozzle to bottom face of plug   Ref. 8

$$F = \left(\frac{\dot{V}\rho}{g_c}\right)\sqrt{v_o^2 - 2gh}$$
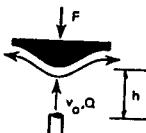
Open Jet on Horizontal Plate

Ref. 7

$\rho = (1.12)(62.4 \text{ lb/ft}^3)$

$\rho = 69.888 \text{ lb/ft}^3$

$g = 32.2 \text{ ft/s}^2$ $g_c = 32.2 \frac{lbm \cdot ft}{lbf \cdot s^2}$

$h = 1.33 \text{ ft}$

$\dot{V} = (680 \text{ gpm})\left(0.002228 \frac{\text{ft}^3/\text{s}}{\text{gpm}}\right) = 1.515 \text{ ft}^3/s$

$v_o = \dfrac{1.515 \text{ ft}^3/s}{\left(\frac{2.0625 \text{ in}}{2(12\text{in/ft})}\right)^2 \pi} = 65.3 \text{ ft/s}$

$$F = \left(\frac{(1.515 \text{ ft}^3/s)(69.888 \text{ lbm/ft}^3)}{32.2 \frac{\text{ft}\cdot\text{lbm}}{\text{lbf}}}\right)\sqrt{(65.3 \text{ ft/s})^2 - 2(32.2 \text{ ft/s})(1.33 \text{ ft})}$$

$F = 212.55 \text{ lbf of lift}$ $< 350 \text{ lb of plug weight}$

☆ G.P.O.   689-996   12/94

Attachment 2
Additional Information from W-320 Design Staff

[7] From: John C Conner at ~HANFORD02B 3/24/97 3:25PM (2208 bytes: 1 ln)
Priority: Urgent
To: Steven E Chalk at ~BCS4, Brit E Hey, John C Van Keuren at ~HANFORD02D,
  Rick J Van Vleet at ~HANFORD02D, David A Himes
Receipt Requested
Subject: Fountain Flow from 2" Flush Connection
--------------------------- Forwarded with Changes ---------------------------
From: Danny L Evans at ~KEH10 3/24/97 12:49PM (1448 bytes: 17 ln)
To: John C Conner at ~HANFORD02B
cc: John W Bailey at ~HANFORD10C, Kerry E Albin at ~HANFORD10B,
  Susan K Farnworth at ~HANFORD07E, Danny L Evans, Theresa K Peterson at
  ~HANFORD07E
Subject: Fountain Flow from 2" Flush Connection
--------------------------- Message Contents ---------------------------
    Forwarded for you attention on the spray leak scenario.

    John C.

_____ Forward Header _____
Subject: Fountain Flow from 2" Flush Connection
Author: Danny L Evans at ~KEH10
Date: 3/24/97 12:49 PM

        W-320's design staff has completed a calculation,
        W320-27-046, examining the lift resulting from an open flush
        connection in the AY-Farm pits. The worst case scenario is,
        the 2" flush connector falls off the sluice line in the
        AY-Farm sluice pit. This leads to an open 2" pipe, a few
        feet from the discharge of the sluice line booster pump.
        The booster pump sees no discharge head and immediately
        jumps to 650 gpm, if running at 3,056 rpm.

        The opening is a 2" pipe, ID 2.067", the pressure above the
        opening is atmospheric pressure 14.4 psia, the discharge
        velocity is 65.3 ft/sec, and the upward force on the 350 lb
        shield plug is 212.5 lbf.

        The shield plug will remain in place. Various instruments
        would report this anomaly and the operators would
        immediately stop sluicing.

[9] From: Danny L Evans at ~KEH10 3/28/97 9:05AM (2163 bytes: 46 ln)
To: David A Himes at ~HANFORD02B
cc: Danny L Evans
Subject: W-320 spray leak
-------------------------- Forwarded with Changes ----------------------------
From: David A Himes at ~HANFORD02B 3/27/97 1:32PM (896 bytes: 17 ln)
To: Danny L Evans at ~KEH10
Subject: W-320 spray leak
---------------------------- Message Contents -----------------------------
          Hi - it's me again. had a few more questions and haven't
          received the copy of your analysis of the open flush
          connection yet.

          Timing was bad; however, the calc was in the mail,
          Wendesday.

          1. you indicated (I think) that the flush connections for
          both the sluice line and the slurry line were up near
          AY-102. Is this right?

          Correct, both the sluice line and slurry line fluxh
          connections are in pit atop AY-102.

          2. Are both flush connections in the same pit or different
          pits? Can you give me the pit number(s)?

          The sluice line flush connection is in the Sluice Pit
          (241-AY-02E).
          The slurry line flush connection is in the Pump Pit
          (241-AY-02A)

          3. What is the approximate volume of the pit(s)
          involved. (inside or outside dimensions would be fine.)

          The inside pit dimensions are (w,l,h):

          02A, Pump Pit, 12'x 8'x 5'
          02E, Sluice Pit, 8'x 6'x 7'

          Both pits include high capacity drains (6" diameter holes)
          in the base plates of installed equipment. The high
          capacity drains are approx. 1" to 4" above the pit low
          points and return liquids to AY-102. The pit low points
          include leak detectors and sump pumps to return small leak
          volumns to AY-102.

          Have a nice day.

          Dave

          Working on one.

          Dan

Attachment 3
SPRAY Code Runfiles

SPRAY Version 3.0
May 3, 1994

Spray Leak Code
Produced by Radiological & Toxicological Analysis
Westinghouse Hanford Company

Run Date = 03/25/97/
Run Time = 12:56:26.97

INPUT ECHO:
c 10% solids sluice line spray - 2 inch pipe
c SPRAY Version 3 Input Deck
c   mode iflow iopt
    1   0   F
c
c MODEL OPTIONS:
c mode = 1 then orifice leak with friction assumed
c   2 then slit leak with friction assumed
c iflow= 0 Reynold's number determines friction relation (i.e. laminar or turb.
c   = 1 friction based on laminar relation
c   = 2 friction based on turbulent relation
c iopt = T then optimal diameter search performed
c   = F then no optimal search
c
c PARAMETER INPUT:
c
c   Initial Slit   Slit or
c   Width or   Slit   Orifice
c   Orifice Dia.   Length   Depth
c   (in)   (in)   (in)
c   _____   _____   _____
    2.06700E+00   0.00000E+00 1.00000E+00
c
c   Absolute
c   Surface
c   Roughness   Contraction   Velocity
c   (in)   Coefficient   Coefficient
c   Pressure   0.00006 tube 0.61   and   0.98 for sharp edge orifice
c   Differential 0.0018 steel 1.00 and   0.98 for rounded orifice
c   (psi)   0.0102 iron   1.00   and   0.82 for square edge orifice
c   _____ _____   _____   _____
    3.80000E+01 1.80000E-03   1.00000E+00 9.80000E-01
c

```
c    Fluid        Dynamic        Respirable     RR Fitting
c    Specific     Viscosity      Diameter       Constant
c    Gravity      (centi-poise)  (μm)           (q)
c    _____  _____  _____    _____
     1.27000E+00  1.00000E+00    2.15000E+01    2.40000E+00
```

MESSAGES:
Orifice Model
User specified orifice diameter or slit width.

OUTPUT:
```
         Liquid Velocity =  6.50E+01 ft/s      1.98E+01 m/s
        Reynolds Number =  1.32E+06 Turbulent Flow
   Sauter Mean Diameter =  4.42E+04 μm
     Respirable Fraction =  4.05E-09
         Total Leak Rate =  6.80E+02 gpm      4.29E-02 m3/s      5.45E+04 g/s
    Respirable Leak Rate =  2.76E-06 gpm      1.74E-10 m3/s      2.21E-04 g/s
```

SPRAY Version 3.0
May 3, 1994

Spray Leak Code
Produced by Radiological & Toxicological Analysis
Westinghouse Hanford Company

Run Date = 03/26/97/
Run Time = 11:12:19.14

INPUT ECHO:
c 33% solids slurry line spray - 2 inch pipe
c SPRAY Version 3 Input Deck
c   mode iflow iopt
     1   0   F
c
c MODEL OPTIONS:
c mode = 1 then orifice leak with friction assumed
c   2 then slit leak with friction assumed
c iflow= 0 Reynold's number determines friction relation (i.e. laminar or turb.
c   = 1 friction based on laminar relation
c   = 2 friction based on turbulent relation
c iopt = T then optimal diameter search performed
c   = F then no optimal search
c
c PARAMETER INPUT:
c
c   Initial Slit   Slit or
c   Width or   Slit   Orifice
c   Orifice Dia.   Length   Depth
c   (in)   (in)   (in)
c   _____   _____ _____
    2.06700E+00   0.00000E+00 1.00000E+00
c
c   Absolute
c   Surface
c   Roughness   Contraction   Velocity
c   (in)   Coefficient   Coefficient
c   Pressure   0.00006 tube 0.61   and   0.98 for sharp edge orifice
c   Differential 0.0018 steel 1.00   and   0.98 for rounded orifice
c   (psi)   0.0102 iron 1.00   and   0.82 for square edge orifice
c   _____ _____   _____   _____
    2.05000E+01 1.80000E-03 1.00000E+00   9.80000E-01
c

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```
c   Fluid          Dynamic        Respirable      RR Fitting
c   Specific       Viscosity      Diameter        Constant
c   Gravity        (centi-poise)  (μm)            (q)
c   _____    _____    _____     _____
    1.41000E+00    1.00000E+00    1.45000E+01     2.40000E+00
```

MESSAGES:
Orifice Model
User specified orifice diameter or slit width.

OUTPUT:
```
       Liquid Velocity =  4.53E+01 ft/s      1.38E+01 m/s
      Reynolds Number =  1.02E+06 Turbulent Flow
 Sauter Mean Diameter =  6.21E+04 μm
  Respirable Fraction =  6.96E-10
      Total Leak Rate =  4.74E+02 gpm      2.99E-02 m3/s      4.22E+04 g/s
 Respirable Leak Rate =  3.30E-07 gpm      2.08E-11 m3/s      2.94E-05 g/s
```

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CHECKLIST FOR PEER REVIEW

Document Reviewed: **RADIOLOGICAL AND TOXICOLOGICAL CONSEQUENCES OF A WORST-CASE SPRAY LEAK RELATED TO PROJECT W-320**, D.A. Himes, 3/31/97

Scope of Review: entire document

Yes No NA

[X] [ ] [ ] *   Previous reviews complete and cover analysis, up to scope of this review, with no gaps.

[X] [ ] [ ]   Problem completely defined.

[X] [ ] [ ]   Accident scenarios developed in a clear and logical manner.

[X] [ ] [ ]   Necessary assumptions explicitly stated and supported.

[X] [ ] [ ]   Computer codes and data files documented.

[X] [ ] [ ]   Data used in calculations explicitly stated in document.

[X] [ ] [ ]   Data checked for consistency with original source information as applicable.

[ ] [ ] [X]   Mathematical derivations checked including dimensional consistency of results.

[X] [ ] [ ]   Models appropriate and used within range of validity or use outside range of established validity justified.

[X] [ ] [ ]   Hand calculations checked for errors. Spreadsheet results should be treated exactly the same as hand calculations.

[X] [ ] [ ]   Software input correct and consistent with document reviewed.

[X] [ ] [ ]   Software output consistent with input and with results reported in document reviewed.

[X] [ ] [ ]   Limits/criteria/guidelines applied to analysis results are appropriate and referenced. Limits/criteria/guidelines checked against references.

[ ] [ ] [X]   Safety margins consistent with good engineering practices.

[X] [ ] [ ]   Conclusions consistent with analytical results and applicable limits.

[X] [ ] [ ]   Results and conclusions address all points required in the problem statement.

[ ] [ ] [X]   Format consistent with appropriate NRC Regulatory Guide or other standards

[ ]   [X] *   Review calculations, comments, and/or notes are attached.

[X] [ ] [ ]   **Document approved.**

John C Van Keuren   JCVanK   4/30/97
Reviewer (Printed Name and Signature)   Date

* Any calculations, comments, or notes generated as part of this review should be signed, dated and attached to this checklist. Such material should be labeled and recorded in such a manner as to be intelligible to a technically qualified third party.

HEDOP REVIEW CHECKLIST
for
Radiological and Nonradiological Release Calculations

Document reviewed (include title or description of calculation, document number, author, and date, as applicable):

Radiological and Toxicological Consequences of a Worst-Case Spray Leak Related to Project W-320, **HNF-SD-WM-CN-102**, Rev. 0, D. A. Himes

Submitted by: D. A. Himes   Date Submitted: 04/30/97

Scope of Review: Entire document

YES   NO*   N/A

[✓]   [ ]   [ ]   1.   A detailed technical review and approval of the environmental transport and dose calculation portion of the analysis has been performed and documented.
[✓]   [ ]   [ ]   2.   Detailed technical review(s) and approval(s) of scenario and release determinations have been performed and documented.
[ ]   [ ]   [✓]   3.   HEDOP-approved code(s) were used.
[✓]   [ ]   [ ]   4.   Receptor locations were selected according to HEDOP recommendations.
[✓]   [ ]   [ ]   5.   All applicable environmental pathways and code options were included and are appropriate for the calculations.
[✓]   [ ]   [ ]   6.   Hanford site data were used.
[ ]   [ ]   [✓]   7.   Model adjustments external to the computer program were justified and performed correctly.
[✓]   [ ]   [ ]   8.   The analysis is consistent with HEDOP recommendations.
[ ]   [✓]   9.   Supporting notes, calculations, comments, comment resolutions, or other information is attached. (Use the "Page 1 of X" page numbering format and sign and date each added page.)

[✓]   [ ]   10. **Approval is granted on behalf of the Hanford Environmental Dose Overview Panel.**

* All "NO" responses must be explained and use of nonstandard methods justified.
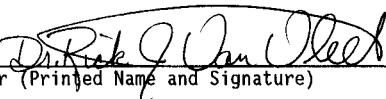
R. J. Van Vleet, Ph.D.   05/09/97
HEDOP-Approved Reviewer (Printed Name and Signature)   Date

COMMENTS (add additional signed and dated pages if necessary):

DISTRIBUTION SHEET

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Project W-320 DE&S Hanford, Inc.	Fluor Daniel Northwest Safety Analysis & Risk Assessment	Date 3/31/97

Project Title/Work Order		EDT No. 621233
Radiological and Toxicological Consequences of a Worst-Case Spray Leak Related To Project W-320		ECN No. N/A

Name	MSIN	Text With All Attach.	Text Only	Attach./ Appendix Only	EDT/ECN Only
J.C. Conner	A2-25	X			
J.P. Harris	S2-48	X			
B.E. Hey	A3-34	X			
J.C. Van Keuren	A3-34	X			
R.J. Van Vleet	A3-34	X			
D.A. Himes	A3-34	X (2)			
Central Files	A3-88	X (Original + 1)			
Docket Files	B1-17	X (2)			
TWRS S&L Files	A2-26	X (2)			