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ENGINEERING DATA TRANSMITTAL

1. EDT 636458

2. To: (Receiving Organization) Nuclear Safety & Licensing	3. From: (Originating Organization) Nuclear Safety & Licensing	4. Related EDT No.: NA
5. Proj./Prog./Dept./Div.: Tank Farms	6. Design Authority/Design Agent/Cog. Engr.: JC Williams	7. Purchase Order No.: NA
8. Originator Remarks: This document is referenced in the Tank Farms DSA.		9. Equip./Component No.: NA
		10. System/Bldg./Facility: Tank Farms
		12. Major Assm. Dwg. No.: NA
11. Receiver Remarks:	11A. Design Baseline Document? ☐ Yes ☒ No	13. Permit/Permit Application No.: NA
		14. Required Response Date:

15. DATA TRANSMITTED

(A) Item No.	(B) Document/Drawing No.	(C) Sheet No.	(D) Rev. No.	(E) Title or Description of Data Transmitted	(F) Approval Designator	(G) Reason for Transmittal	(H) Originator Disposition	(I) Receiver Disposition
1	RPP-13438	NA	0	Technical Basis for the Tank Bump Representative Accident and Associated Hazardous Conditions	N/A	1	1	1

16. KEY

Approval Designator (F)	Reason for Transmittal (G)	Disposition (H) & (I)
E, S, Q, D OR N/A (See WHC-CM-3-5, Sec. 12.7)	1. Approval 2. Release 3. Information 4. Review 5. Post-Review 6. Dist. (Receipt Acknow. Required)	1. Approved 2. Approved w/comment 3. Disapproved w/comment 4. Reviewed no/comment 5. Reviewed w/comment 6. Receipt acknowledged

17. SIGNATURE/DISTRIBUTION (See Approval Designator for required signatures)

(G) Reason	(H) Disp.	(J) Name	(K) Signature	(L) Date	(M) MSIN	(G) Reason	(H) Disp.	(J) Name	(K) Signature	(L) Date	(M) MSIN
		Design Authority NA									
		Design Agent NA									
1	1	Cog. Eng. J.C. Williams	[signature]	3/21/03	E6-17						
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		QA NA									
		Safety NA									
		Env. NA									

18.	19.	20.	21. DOE APPROVAL (if required)
[signature] JC Williams 3/21/03	[signature] JM Grigsby 3/21/03	[signature] JM Grigsby 3/21/03	Ctrl No. NA
Signature of EDT Originator / Date	Authorized Representative for Receiving Organization / Date	Design Authority/ Cognizant Manager / Date	☐ Approved ☐ Approved w/comments ☐ Disapproved w/comments

DISTRIBUTION SHEET

To	From	Page 1 of 1
CH2M HILL Hanford Group, Inc.	Nuclear Safety & Licensing	Date 3/21/2003
Project Title/Work Order		EDT No. 636458
RPP-13438, "Technical Basis for the Tank Bump Representative Accident and Associated Hazardous Conditions"		ECN No. N/A

Name	MSIN	Text With All Attach.	Text Only	Attach./ Appendix Only	EDT/ECN Only
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A-6000-135 (10/97)

Technical Basis for the Tank Bump Representative Accident and Associated Hazardous Conditions

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CH2M HILL Hanford Group, Inc.
Richland, WA 99352
U.S. Department of Energy Contract DE-AC27-99RL14047

EDT/ECN: 636458 UC: N/A
Cost Center: 7B300 Charge Code: 501570
B&R Code: N/A Total Pages: 42

Key Words:
Tank Bump Accident, Safety Basis, Single-Shell Tanks, Double-Shell Tanks, Tank Waste Boiling, Loss of Cooling

Abstract:
This document provides the technical basis for the radiological and toxicological consequences of a tank bump representative accident and associated hazardous conditions.

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3/21/03
Release Approval Date

DATE: HANFORD RELEASE
STA: 4 ID: 2
MAR 21 2003
Release Stamp

Approved For Public Release

RPP-13438
Revision 0

Technical Basis for the Tank Bump Representative Accident and Associated Representative Hazardous Conditions

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

CH2MHILL
Hanford Group, Inc.

Richland, Washington

Contractor for the U.S. Department of Energy
Office of River Protection under Contract DE-AC27-99RL14047

Approved for public release; further dissemination unlimited

RPP-13438
Revision 0

Technical Basis for the Tank Bump Representative Accident and Associated Representative Hazardous Conditions

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Date Published
March 2003

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LIST OF TERMS

DSA	Tank Farms Documented Safety Analysis
DST	double-shell tank
HEPA	high-efficiency particulate air (filter)
LCO	limiting conditions for operation
SMP	safety management program
SOF	sum of fractions
SSC	structures, systems, and components
SST	single-shell tank
TEEL	Temporary Emergency Exposure Limit
TSR	technical safety requirement
TWG	Technical Working Group
ULD	unit-liter dose

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1.0 INTRODUCTION

1.1 PURPOSE

This technical basis document was developed to support the Tank Farms Documented Safety Analysis (DSA) and describes the risk binning process and the technical basis for assigning risk bins for the tank bump representative accident and associated hazardous conditions. The purpose of the risk binning process is to determine the need for safety-significant structures, systems, and components (SSC) and/or technical safety requirement (TSR)-level controls for a given representative accident or represented hazardous conditions based on an evaluation of the frequency and consequence. Note that the risk binning process is not applied to facility workers, because all facility worker hazardous conditions are considered for safety-significant SSCs and/or TSR-level controls. (See RPP-14286, *Facility Worker Technical Basis Document.*) Determination of the need for safety-class SSCs was performed in accordance with DOE-STD-3009-94, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports*, as described below.

1.2 BACKGROUND INFORMATION

1.2.1 Representative Accident

A tank bump is a postulated event in which gases, consisting mostly of water vapor, are suddenly emitted from the waste and cause tank headspace pressurization. A tank bump is distinguished from a gas release event in two respects: first, the physical mechanism for release involves vaporization of locally superheated liquid; and second, gases emitted to the head space are not flammable. For this reason, a tank bump is often called a steam bump.

In this analysis, even though non-condensible gases may be considered in bump models, flammability and combustion of emitted gases are not. Generation and release of flammable or combustible gases is treated in RPP-13510, *Flammable Gas Technical Basis Document.*

The following paragraphs summarize the current understanding of the mechanisms involved in tank bumps and describe the conditions that must be present for a tank bump to occur. This is a summary of information presented in RPP-6213, *Hanford Waste Tank Bump Accident and Consequence Analysis.*

- The sludge layer must have sufficient heat generation so that it can heat a region of the sludge to the saturation temperature in that region. The heat generation rate must be sufficient for some part of the sludge to reach saturation temperature. Gas bubbles can accumulate in this area of the sludge to the point where the sludge density is less than the covering supernatant density. If the buoyant force exceeds the sludge shear strength, the affected volume of sludge can break loose. A tank with a heat load less than 11.3 kW is not susceptible to a tank bump.

- There must be a significant sludge (non-convective) layer in the tank. If the sludge layer is not thick, high local temperatures will not occur because the heat can be removed by conduction to the soil and/or supernatant, and convection from the supernatant to the headspace gas. A tank with a non-convective layer thinner than 0.3 m is not susceptible to a tank bump.

- The material properties of the sludge must be such that net retention of non-condensible gases occurs and can eventually lead to neutral buoyancy. Water vapor will enter these gas bubbles at an increasing rate as local saturation temperature is approached. Eventually, buoyant displacement of non-condensible gases and steam initiates the bump.

- There must be a sufficient supernatant layer (convective layer) such that a rising waste parcel is locally superheated, causing rapid expansion of existing bubbles. The deep supernatant layer must be near its saturation point. This growth and release of gas and steam increases the headspace pressure. If the supernatant is too cool, bubbles from the sludge layer will lose sufficient heat such that bubbles will not grow and a bump will not occur. A tank with a convective layer less than 1 m is not susceptible to a tank bump.

An analysis in RPP-6213 evaluated all single-shell tanks (SST) and double-shell tanks (DST) for the probability and consequences of a tank bump, and no SSTs were found to be susceptible. The DSTs that are susceptible to a tank bump are DSTs 241-AY-102, 241-AZ-101, and 241-AZ-102 (all other DSTs had insufficient heat load). All susceptible tanks are in the Aging Waste Facility (AWF). The heatup time developed in this analysis is bounded by DST 241-AZ-101, which has a heat load of approximately 61 kW. The other susceptible DSTs have lower heat loads and heatup rates. Although DST 241-AZ-101 has the fastest heatup rate during a loss of cooling event, tank bump consequences are influenced by other waste conditions, notably the settled solids or non-convective layer depth. For this reason, a consequence evaluation for a tank bump in all susceptible tanks is presented.

1.2.2 Bounding Offsite Accident

A tank bump is a moderate energy atmospheric vapor/gas/aerosol release event that is bounded by the tank failure due to excessive loads accident, which has been quantitatively analyzed for comparison to the DOE-STD-3009-94, Appendix A, "Evaluation Guideline" of 25 rem. The bounding quantitative analysis for the tank failure due to excessive loads accident is documented in RPP-12395, *Offsite Radiological Consequences of Waste Tank Dome Failure*, and shows that offsite radiological consequences are less than 1 rem; therefore, no safety-class equipment or TSR-level controls need to be considered for offsite radiological exposures for any of the moderate energy atmospheric vapor/gas/aerosol release events. It is important to note that DOE-STD-3009-94 does not provide any other evaluation guidelines (i.e., evaluation guidelines are not provided for offsite toxicological, onsite radiological and toxicological). These exposures were evaluated for the tank bump accident and associated hazardous conditions in accordance with the risk binning process described in Section 1.3.

1.2.3 Associated Hazardous Conditions

In addition to the hazardous condition that defines the representative accident, the current hazards evaluation database lists a number of hazardous conditions that are represented by the tank bump accident. Some of these hazardous conditions result from another cause, but were assigned to the tank bump representative accident because these events all involve moderate energy releases caused by high heat and/or loss of ventilation.

1.3 RISK BINNING METHODOLOGY

The risk binning process was conducted in accordance with direction provided by the U.S. Department of Energy, Office of River Protection (Klein and Schepens, 2003, "Replacement of Previous Guidance Provided by RL and ORP"). Risk binning begins with a qualitative evaluation of the frequency and consequence of the representative accident. Consequences are evaluated for the following receptors and exposures: offsite toxicological, onsite radiological, and onsite toxicological. These consequences are assigned to one of three categories: high, moderate, or low. Based on the frequency and consequence, risk bins (ranging from I to IV) are assigned. It is important to note that for offsite toxicological, onsite radiological, and onsite toxicological exposures, safety SSCs and/or TSR-level controls are required for accidents or hazardous conditions that are assigned to risk bins I or II, and are considered for accidents or hazardous conditions that are assigned to Risk Bin III. For accidents or hazardous conditions assigned to Risk Bin IV, safety SSCs and TSR-level controls are not expected. Safety management programs (SMP) are acceptable for addressing the residual risk posed by Risk Bin IV conditions. Table 1 and 2 show the criteria for assigning the frequency and consequence categories, and the risk bins, which are assigned to the various combinations of frequency and consequence. After the risk binning process is completed for the representative accident, the process is then repeated for the represented hazardous conditions associated with the representative accident.

Table 1. Offsite (Toxicological Only) Risk Bins.

Consequence category (toxicological only[1])	Event frequency			
	$<10^{-6}$/yr Beyond extremely unlikely	**10^{-4} to 10^{-6}/yr Extremely unlikely**	**10^{-2} to 10^{-4}/yr Unlikely**	**$>10^{-2}$/yr Anticipated**
>ERPG-2/TEEL-2 (High)	III	II	I	I
>ERPG-1/TEEL-1 <ERPG-2/TEEL-2 (Moderate)	IV	III	II	I
<ERPG-1/TEEL-1 (Low)	IV	IV	III	III

safety-significant SSCs and/or TSR-level controls required.

safety-significant SSCs and/or TSR-level controls considered.

[1] Radiological consequences for the offsite receptor are evaluated in accordance with DOE-STD-3009, 2002-94, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Documented Safety Analyses*, Change Notice No. 2, Appendix A, U.S. Department of Energy, Washington D.C.

ERPG = emergency response planning guideline.
SSC = structures, systems, and components.
TEEL = Temporary Emergency Exposure Limit.
TSR = technical safety requirement.

Table 2. Onsite (100 m) Risk Bins.

Consequence category (radiological/ toxicological)	Event frequency			
	$<10^{-6}$/yr Beyond extremely unlikely	**10^{-4} to 10^{-6}/yr Extremely unlikely**	**10^{-2} to 10^{-4}/yr Unlikely**	**$>10^{-2}$/yr Anticipated**
>100 rem >ERPG-3/ TEEL-3 (High)	III	II	I	I
25 to 100 rem >ERPG-2/TEEL-2 <ERPG-3/TEEL-3 (Moderate)	IV	III	II	I
<25 rem < ERPG-2/TEEL-2 (Low)	IV	IV	III	III

safety-significant SSCs and/or TSR-level controls required.

safety-significant SSCs and/or TSR-level controls considered.

ERPG = emergency response planning guideline.
SSC = structures, systems, and components.
TEEL = Temporary Emergency Exposure Limit.
TSR = technical safety requirement.

Environmental consequences are also assigned during the risk binning process. There are four categories of environmental consequences (E0, E1, E2, and E3, in order fo increasing severity); these categories are defined in Table 3.

Table 3. Environmental Consequence Categories.

Category	Definition
E3	Offsite discharge or discharge to groundwater
E2	Significant discharge onsite
E1	Localized discharge of hazardous material
E0	No significant environmental consequence

2.0 RISK BINNING RESULTS

A risk binning team meeting was conducted on September 26, 2002, to obtain consensus on the assignment of frequencies, consequences, and risk bins. The attendees represented a wide range of expertise in the areas of engineering, licensing, and operations, and included representatives from the U.S. Department of Energy, Office of River Protection. Appendix A lists the attendees and the organization each attendee represents. After the meeting, the risk binning results were distributed to the Technical Working Group (TWG) for review and concurrence. The TWG concurred with the final risk bin results, which are shown in Table 4 (RPP-15116, *Proceedings of the Nuclear Working Group and the Technical Working Group*).

Table 4. Summary of Results for Representative Scenarios. (2 sheets)

Postulated accident/Hazardous condition	Frequency	Consequences				Risk bin		
		Onsite radiological	Offsite toxicological	Onsite toxicological	Environmental	Onsite radiological	Offsite toxicological	Onsite toxicological
Long-term loss of ventilation airflow caused by power outage results in tank bump.	U	L	L	M	E1	III	III	II
Long-term loss of ventilation airflow and transfer pump operation in recirculation mode results in tank bump.	U	L	L	M	E1	III	III	II
Loss of ventilation airflow caused by a plugged exhaust HEME/HEGA/HEPA filter results in tank bump.	U	L	L	M	E1	III	III	II
Loss of ventilation airflow caused by a plugged inlet filter results in an increase in tank vacuum, causing a tank bump.	EU	L	L	M	E1	IV	IV	III
Long-term loss of ventilation airflow caused by power outage results in tank waste boiling.	U	L	L	L	E1	III	III	III
SST boiling or flashing.	BEU	L	L	L	E1	IV	IV	IV
Dome collapse caused by tank bump.	BEU	L	L	M	E1	IV	IV	IV

Table 4. Summary of Results for Representative Scenarios. (2 sheets)

Postulated accident/Hazardous condition	Frequency	Consequences				Risk bin		
		Onsite radiological	Offsite toxicological	Onsite toxicological	Environmental	Onsite radiological	Offsite toxicological	Onsite toxicological

Notes:

BEU	= beyond extremely unlikely.	HEPA	= high-efficiency particulate air (filter).
EU	= extremely unlikely.	L	= low.
HEGA	= high-efficiency gas adsorber.	M	= moderate.
HEME	= high-efficiency mist eliminator.	SST	= single-shell tank.
		U	= unlikely.

2.1 TANK BUMP REPRESENTATIVE ACCIDENT WITHOUT CONTROLS

2.1.1 Scenario

The saturation temperature of tank liquid waste for the bounding case, 241-AZ-101, is 104 °C (220 °F) (RPP-14892, *Boiling Point Calculation for Selected Double-Shell Tanks*) at atmospheric pressure because of the dissolved salt content in the waste. Hydrostatic head for the total waste height (including sludge) increases local pressure and saturation temperature. A significant tank bump will not occur if the liquid waste is sub-cooled by 10 °F; i.e., if the temperature is 210 °F (RPP-6213, Figure 4-5).

For the bounding tank bump scenario, it is postulated that the DST Primary Ventilation System fails for an indefinite amount of time. DST 241-AZ-101 has a total heat load of approximately 61 kW, and the heatup rate of the waste in the tank has been calculated to be 0.6 °F/day following a loss of cooling (RPP-6213). A key assumption of this analysis is that the waste supernatant temperature is less than or equal to 195 °F when the loss of power occurs. It would take 25 days for the tank to reach bump conditions ([210 °F – 195 °F]/ 0.6 °F/day = 25 days) following a loss of power. It is also important to note that the maximum temperature of the tank waste is normally much lower than 195 °F (e.g., <165 °F). A lower starting temperature after a loss of cooling capability would provide significantly more margin to saturation than that assumed here in the analysis without controls. Another key assumption is that 61 kW is the maximum tank heat load.

2.1.2 Frequency Determination

It is expected that extreme conditions would be necessary to cause a failure of the tank waste cooling capability that would approach 25 days. The only event judged to be capable of producing such extreme conditions is an earthquake, which causes such widespread damage that the ventilation system remains inoperable.

A frequency of "unlikely" was qualitatively assigned to this accident based on the expected frequency of the initiating event (e.g., design basis earthquake resulting in long-term loss of power) and heating of the tank waste.

2.1.3 Consequence Determination

Consequences are calculated for all three tanks that are susceptible to a bump.

Source Term

The source term was calculated based on waste information (sludge depth, supernatant depth, waste chemical and physical properties, etc.) for individual tanks that was taken from RPP-5926, *Steady-State Flammable Gas Release Rate Calculation and Lower Flammability Level Evaluation for Hanford Tank Waste*. This use of tank-specific waste information is a key assumption of this analysis.

The source term was calculated using analytical models that are described in RPP-6213. The analytical model includes mass and heat transfer and calculates bubble, gas, and aerosol dynamics. The model includes the tank headspace, ventilation system, pump pits, and structures. The growth of bubble volume causes a rise in the supernatant level and pressure increase in the tank headspace, which the model calculates. The headspace gas can leave through the inlet and outlet ventilation paths. Leakage paths are also comprised of drains in the four sluice pits and center pit. As the bubbles break through the surface, they release vapor and gas and cause ejection of a supernatant spray into the headspace. The model assumes complete mixing in the headspace and calculates temperatures, pressures, and aerosol entrainment and deposition. The increased pressure causes a flow of aerosol-laden air from the headspace to any available pressure-relief path, but mostly through the ventilation system. The model considers material at risk, damage ratio, airborne release fraction, and leak path factor.

The steam entering the headspace expands to a saturated state. The model predicts the total amount of aerosols released to the environment, the elapsed time, the number of bumps, and the interval between bumps (RPP-6213). The source terms are summarized below. All of the released material is conservatively estimated to be respirable.

Source Term Summary					
Tank	Total Source Term (kg)	Liquid Source Term (L)	Solid Source Term (L)	Number of Bumps	Interval Between Bumps
241-AY-102	0.6	0.49	0.03	11	~18 hours
241-AZ-101	2.6	2.22	0.08	6	~30 sec
241-AZ-102	3.7	3.26	0.14	6	~14 hours

The first pressure spike is approximately 3.6 lb/in^2 gauge, which is sufficient to cause failure of the high-efficiency particulate air (HEPA) filters (assumed to fail at ~1.3 lb/in^2 [DOE-HDBK-3010-94, *Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities*]). Therefore, the airborne material generated is assumed to enter the environment unfiltered. The HEPA filters, which are in the pressure release path, are likely to contain a small amount of contamination from normal tank operation prior to the tank bump and are assumed to fail catastrophically. The ventilation system for the 241-AY and 241-AZ tank farms releases the equivalent of only 5.35E-05 L of DST waste (RPP-13437, *Technical Basis Document for Ventilation System Filtration Failure Leading To An Unfiltered Release*). This quantity of material is very small compared to the amount of aerosolized material released

from the tank due to the tank bump event. Therefore, it can be concluded that the consequences of a release from the filters due to failure by the pressure spike is negligible compared to the consequences of the airborne material released from the headspace because of the bump.

Radiological Consequences

The radiological consequences are calculated with the method described in RPP-13842, *Atmospheric Dispersion Coefficients and Radiological/Toxicological Exposure Methodology for Use In Tank Farms*, using the equation:

$$D = (Q_L \times ULD_L + Q_S \times ULD_S) \times \chi/Q' \times BR$$

where:

D	=	radiological consequences in Sv
Q_L	=	liquid source term in L
Q_S	=	solids source term in L
ULD_L	=	liquid unit liter dose in Sv/L
ULD_S	=	solids unit liter dose in Sv/L
X/Q'	=	atmospheric dispersion coefficient in s/m^3
BR	=	breathing rate in m^3/s.

The breathing rate is 3.33E-04 (RPP-5924, *Radiological Source Terms for Tank Farms Safety Analysis*). The onsite χ/Q' is conservatively taken to be for a 2-hr release with plume meander, and is 9.40E-03 s/m^3 (RPP-13482). A key assumption of this analysis is the use of tank-specific unit-liter doses (ULD) from RPP-5924. They are summarized below:

Tank Waste Unit-Liter Doses (ULD)		
Tank	ULD, Sv/L	
	Liquid	Solid
241-AY-102	1.4E+01	3.1E+04
241-AZ-101	4.0E+02	1.9E+05
241-AZ-102	2.6E+02	6.4E+04

The onsite radiological consequences are calculated to be:

Onsite Radiological Consequences		
Tank	Sieverts	rems
241-AY-102	2.9E-03	2.9E-01
241-AZ-101	5.04E-02	5.04
241-AZ-102	3.07E-02	3.07

Toxicological Consequences

Toxicological consequences are also calculated with the method described in RPP-13842, using the equation:

$$T = (Q_L \times SOF_L + Q_S \times SOF_S) \times /Q' / d$$

where:

T	=	toxicological sum of fractions consequences
Q_L	=	liquid source term in L
SOF_L	=	liquid sum of fractions multiplier
Q_S	=	solids source term in L
SOF_S	=	solids sum of fractions multiplier
ULD_L	=	liquid unit-liter dose in Sv/L
ULD_S	=	solids unit-liter dose in Sv/L
χ/Q'	=	atmospheric dispersion coefficient in s/m^3
d	=	event duration in seconds.

The tank bumps for DSTs 241-AY-102 and 241-AZ-102 consist of several small bumps that are many hours apart. For this reason, unlike the radiological consequences, which are based on a continuous exposure, the toxicological consequences for these tanks are based on the worst-case individual release. The release is modeled as a continuous release over 60 sec. Because the waste concentration in the tank headspace does not completely fall out after each bump, the concentration gradually increases and so the worst-case release is the final one. The individual release source term is estimated to be total source term divided by the number of bumps, plus a multiplier of 20% to account for aerosol buildup in the tank headspace during the series of bumps. The magnitude of the multiplier is estimated from RPP-6213, Figure 8-2 (the consequences do not depend strongly on this multiplier).

Because the releases from DST 241-AZ-101 occur in rapid succession, they are modeled as a single continuous release that occurs over 3 min (RPP-6213).

The onsite and offsite χ/Q's are conservatively taken to be for a 1-hr release without plume meander, and are 3.28E-02 s/m^3 and 2.22E-05 s/m^3, respectively (RPP-13482). A key assumption of this analysis is the use of tank-specific sums of fractions (SOF) from Appendix G of RPP-8369, *Chemical Source Terms for Tank Farms Safety Analyses*. They are summarized below:

Tank Waste Sums of Fractions				
Tank	Waste Type	TEEL-1	TEEL-2	TEEL-3
241-AY-102	Liquid	5.68E+08	7.24E+07	2.19E+06
	Solid	8.47E+08	4.58E+08	5.94E+07
241-AZ-101	Liquid	8.55E+08	1.14E+08	3.06E+06
	Solid	8.25E+08	5.00E+08	3.79E+07
241-AZ-102	Liquid	4.33E+08	6.18E+07	1.47E+06
	Solid	9.31E+08	5.15E+08	3.63E+07

The toxicological consequences were calculated based on SOFs for "low" consequences, i.e., Temporary Emergency Exposure Limit -1 (TEEL) for the offsite receptor and TEEL-2 for the onsite receptor. Onsite toxicological consequences were also calculated based on the TEEL-3 SOFs for "moderate" consequences (see Tables 1 and 2).

Toxicological Consequences			
Tank	241-AY-102	241-AZ-101	241-AZ-102
Onsite	2.9	53	30
Offsite	1.2E-02	0.24	0.11
Onsite (TEEL-3)	0.17	1.8	1.1

Although the onsite toxicological consequences for some tanks exceed the "moderate" guideline, the consequences were qualitatively evaluated as "moderate" rather than "high," based on the many conservatisms inherent in the model. For example, use of the bounding 1-hour χ/Q (3.28E-02 s/m^3) neglects the momentum and buoyancy effects of the plume, neglects thermal rise of the plume, and neglects volumetric release adjustments. All of these effects would be expected in a pressurized release of high-temperature (>200 °F) aerosol material, and would reduce the χ/Q. By comparison, the bounding moderate energy atmospheric vapor/gas/aerosol release event, tank failure due to excessive loads, uses a χ /Q of 1.98E-03 (RPP-12444, *Technical Basis for the Tank Failure Due to Excessive Loads Representative Accident and Associated Represented Hazardous Conditions*). The onsite χ /Q for a vehicle fuel tank fire is 6.98E-04 (RPP-13978, *Technical Basis for the Transportation Related Handling Representative Accidents and Associated Hazardous Conditions*), the χ /Q for fire in contaminated area is 6.23E-04 (RPP-13354, *Technical Basis for the Release from Contaminated Facility Representative Accident and Associated Represented Hazardous Conditions*). Other conservatisms present in the HADCRT code (e.g., leak path factor) are explained in RPP-6213.

Key Assumptions

This analysis contains three key assumptions:

- The initial temperature of the waste supernatant is 195 °F. This is reasonably conservative, since recent operational experience has shown no tank temperatures over 165 °F for several years.

- The maximum tank heat load is 61 kW (DST 241-AZ-101). This is reasonably conservative, since Tank 241-AZ-101 has a significantly higher heat load than any other tank.

- Existing tank contents (from RPP-5926) are used to calculate the source term. This assumption is based on the fact that there are no plans to significantly alter the contents of the AWF tanks prior to the waste feed delivery mission (the AWF tanks will comprise the

first batches of high-level waste sent to the Waste Treatment Plant [RPP-8218, *Generalized Feed Delivery Descriptions and Tank Specific Flowsheets*]). Use of the existing tank contents also affects the selection of ULDs and SOFs.

A sensitivity analysis in RPP-6213 concluded that a hypothetical tank that is filled to the operating limit with 50% solids and 50% liquid would produce the bounding source term (9 kg). If this source term were combined with bounding ULDs and SOFs, the onsite toxicological consequences would be sufficiently high to change the risk bin. Since no existing tank resembles this, and creation of such a tank by waste transfers is considered unlikely, this sensitivity is not considered further.

Assumption Sensitivities

Assumptions are listed in Table 5. It is important to note that the analysis assumptions listed in Table 5 were selected to maximize the calculated consequences of the tank bump accident and that it is the combination of conservative assumptions that actually drive the accident consequences. The sensitivity of the key assumptions and input parameters, including the potential effect of changes in the assumption on the frequency or consequence level (qualitatively judged), and the need to protect the assumptions are detailed in Table 5.

Table 5. Qualitative Evaluation of Analysis Assumptions for Representative Accidents. (4 sheets)

Analysis assumptions (AA) with references/basis	Assumption type	Potential effect on risk bin	Need to protect AA	Protection basis
The initial waste supernatant temperature is less than or equal to 195 °F.	Reasonably conservative. Typical tank temperature is <165 °F.	The difference between the initial temperature and the saturation temperature determines the heatup time, which is the qualitative basis for the "unlikely" accident frequency. Heatup time has no effect on accident consequences.	Yes	The safety-significant DST Primary Ventilation System maintains the waste at the required temperature.
The maximum tank heat load is 61 kW.	Reasonably conservative. This is the highest measured heat load of any DST.	A higher heat load would reduce the heatup time, which is the qualitative basis for the "unlikely" accident frequency. Heatup time has no effect on accident consequences.	No	There are no plans to significantly alter the current contents of the AWF tanks prior to the Waste Feed Delivery mission.
The toxicological source term (final bump) is modeled as the total release divided by the number of bumps, plus a multiplier of 20% to account for aerosol buildup in the tank headspace during the series of bumps.	Reasonably conservative.	No anticipated effect on consequence level. The multiplier can vary up to 75% without affecting the risk bin.	No	N/A
Sludge shear strength is 100 Pa (RPP-6213).	Reasonably conservative. Shear strength varies with depth. This is purely a modeling assumption.	No anticipated effect on consequence level. High shear strength produces a few big bumps over a long period of time. Low shear strength produces many small bumps occurring in rapid succession. Over the course of many hours, the two effects roughly cancel out and the releases do not vary markedly with shear strength.	No	N/A
The HEPA filters are assumed to fail. No credit is taken for effluent retention by the filters (RPP-6213).	Bounding (physically limiting). This is a conservative assumption that is made for the "no controls" scenario.	No anticipated effect on consequence level. Taking credit for particulate removal by the filters would reduce the accident consequences.	No	N/A

Table 5. Qualitative Evaluation of Analysis Assumptions for Representative Accidents. (4 sheets)

Analysis assumptions (AA) with references/basis	Assumption type	Potential effect on risk bin	Need to protect AA	Protection basis
The RF is 1 (i.e., all material released to the environment is respirable) (RPP-6213).	Bounding (physically limiting).	No anticipated effect on consequence level. Use of an RF less than 1 would reduce consequences.	No	N/A
Breathing rate used to calculate onsite radiological consequences is 3.33E-04 m^3/s (RPP-5924). This is the breathing rate associated with light activity (i.e., it is an 8-hr average, assuming 2.5 hr of sitting and 5.5 hr of light exercise) as derived by the International Commission on Radiological Protection.	Reasonably conservative. This is a standard analysis assumption.	No anticipated effect on consequence level. Use of a different breathing rate would have a linear effect on radiological consequences.	No	N/A
The waste information used to calculate accident source term is based on individual tank contents (RPP-5926).	Best estimate.	If a tank were full of 50% solids and 50% supernatant, the source term would increase to 9 kg. If the bounding ULDs and SOFs were used, the consequences could increase to Risk Bin I.	No	There are no plans to significantly alter the current contents of the AWF tanks prior to the Waste Feed Delivery mission.
ULDs used to calculate onsite radiological consequences are based on individual tank contents (RPP-5924).	Best estimate.	No anticipated effect on consequence level. Use of the bounding ULD would increase radiological consequences, but not enough to change the risk bin.	No	There are no plans to significantly alter the current contents of the AWF tanks prior to the Waste Feed Delivery mission.
SOFs used to calculate onsite toxicological consequences are based on individual tank contents (RPP-8369).	Best estimate.	No anticipated effect on consequence level. Use of the bounding SOF would increase toxicological consequences enough to change the risk bin.	No	There are no plans to significantly alter the current contents of the AWF tanks prior to the Waste Feed Delivery mission.

Table 5. Qualitative Evaluation of Analysis Assumptions for Representative Accidents. (4 sheets)

Analysis assumptions (AA) with references/basis	Assumption type	Potential effect on risk bin	Need to protect AA	Protection basis
χ/Q' used to calculate onsite radiological consequences is 9.40E-03 s/m^3. This is the 95th-percentile value for a 2-hr release with plume meander (RPP-13482).	Reasonably conservative. All tank bump accidents occur over a longer period of time than 2 hr.	No anticipated effect on consequence level.	No	N/A
χ/Q's used to calculate onsite toxicological consequences are 3.28E-02 s/m^3 (onsite) and 2.22E-05 s/m^3 (offsite). These are the 95th-percentile values for a 1-hr release with no plume meander (RPP-13482).	Reasonably conservative. Individual bump is modeled as a 60-sec release (241-AY-102, 241-AZ-102). Rapid series of bumps is modeled as a 180-sec release (241-AZ-101). Neglect of plume meander is appropriate for a short-term (<1-hr) release.	No anticipated effect on consequence level.	No	N/A
HADCRT assumes actual headspace volumes as input when calculating the source terms (RPP-6213).	Reasonably conservative. Use of minimum headspace volume as an input assumption can lead to non-conservative source term calculations, because the smaller headspace can squelch the bump.	No anticipated effect on consequence level.	No	N/A
Leakage paths from the tank headspace are gaps around the 42 in. riser shield plugs, and inlet/outlet ducts are assumed open to the atmosphere (RPP-6213).	Bounding (physically limiting). The exhaust ductwork of the AZ-702 ventilation system includes significant flow restriction and plateout area.	No anticipated effect on consequence level. Assuming the exhaust ductwork is closed off could reduce the source term by approximately a factor of two. Assuming the exhaust ductwork is open, but allowing for plateout, could reduce the source term by less than an order of magnitude.	No	N/A
Aerosol retention in sluice and pump pits is not credited.	Bounding (physically limited).	No anticipated effect on consequence level. Crediting this retention would slightly reduce consequences.	No	N/A

Table 5. Qualitative Evaluation of Analysis Assumptions for Representative Accidents. (4 sheets)

Analysis assumptions (AA) with references/basis	Assumption type	Potential effect on risk bin	Need to protect AA	Protection basis

Notes:

RPP-5924, 2003, *Radiological Source Terms for Tank Farms Safety Analysis,* Rev. 1, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-5926, 2003, *Steady-State Flammable Gas Release Rate Calculation and Lower Flammability Level Evaluation for Hanford Tank Waste,* Rev. 2A, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-6213, 2003, *Hanford Waste Tank Bump Accident and Consequence Analysis*, Rev. 2, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-8369, 2003, *Chemical Source Terms for Tank Farms Safety Analyses*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-13842, 2003, *Atmospheric Dispersion Coefficients and Radiological/Toxicological Exposure Methodology for Use in Tank Farms*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

AA = analysis assumption.
AWF = Aging Waste Facility.
DST = double-shell tank.
HEPA = high-efficiency particulate air (filter).
N/A = not applicable.
RF = respirable fraction.
SOF = sum of fractions.
ULD = unit-liter dose.

2.1.3.1 Assignment of Consequence Bins for the Onsite Receptors

In determining the offsite toxicological and onsite radiological and toxicological consequences bins, the meeting participants considered the actual operational experience where a tank bump-type event produced only a small pressure increase in the feed tank, as well as the existing analysis which applied a combination of conservative assumptions to calculate radiological and toxicological consequences. These calculated consequences are low when compared to the guidelines (i.e., the onsite radiological consequence of 5 rem <25 rem and the offsite toxicological consequences [SOFs] of 0.24 <1 [TEEL-1]). Therefore, a consequence bin of "low" was assigned to the onsite radiological and offsite toxicological exposures. However, the onsite toxicological consequence exceeds 1 (TEEL-2 and TEEL-3). As described in Section 2.1.3, a consequence bin of "moderate" was qualitatively assigned to the onsite toxicological exposure.

2.1.3.2 Assignment of Environmental Consequences

Based on operational experience and the conservative calculations in RPP-6213, where the estimated release was 3.7 kg of waste, it was concluded that there is limited potential for material release to either the atmosphere or ground. Therefore, an environmental consequence of E1 was assigned to the tank bump representative accident.

2.1.3.3 Assignment of Risk Bins

As discussed previously, the frequency of the tank bump was considered to be in the "unlikely" range and the offsite toxicological and onsite radiological consequences were all assigned a consequence bin of "low." The onsite toxicological consequences were qualitatively assigned a consequence bin of "moderate." Therefore, each exposure category for the tank bump representative accident was assigned to Risk Bin III, with the exception of onsite toxicological (which was assigned to Risk Bin II).

2.2 TANK BUMP - ASSOCIATED HAZARDOUS CONDITIONS

There are several additional hazardous conditions represented by the tank bump representative accident. The results of the risk binning process for these hazardous conditions are shown in the hazard evaluation database under representative accident (Rep Acc) 18A. Included in hazard evaluation database entries is a basis for each consequence and frequency.

As noted previously, some of these hazardous conditions result from causes other than a tank bump, but were assigned to the tank bump representative accident because these events all involve moderate energy releases caused by high heat and/or loss of ventilation. Consensus was reached that all the represented hazardous conditions were bounded by the representative accident. One key assumption influenced the frequency of the hazardous conditions associated with SST 241-SX-114. Another key assumption involved the influence of transfer pump operation on the frequency of a tank bump. Other key assumptions influenced the frequency of a tank bump caused by a plugged filter (instead of loss of power), the frequency of waste boiling resulting from a loss of power, and the frequency of a tank bump that results in a dome collapse. These key assumptions are described in Table 6.

Double-Shell Tank Supernatant Boiling

One of the associated hazardous conditions (102AW-02-TEMP01) is that the high heat caused by long-term loss of cooling causes the waste supernatant to boil. The waste release rate is 0.06 kg/day (RPP-15088, *Consequences of Select Boiling Waste Scenarios For Waste Feed Delivery*). The waste is conservatively assumed to consist of bounding DST liquids, with a density of 1.1 kg/L (RPP-5926). Using this source term and the methodology described in Section 2.1.3 for continuous exposure, the onsite radiological consequences are 6 millirem. The onsite and offsite toxicological consequences are 2.05×10^{-3} and 3.01×10^{-5}, respectively. These consequences are all below guidelines.

The initiator for tank waste boiling is the same as for tank bump, i.e., the long-term loss of tank ventilation. For this reason, the frequency of tank waste boiling is also considered "unlikely," and the onsite radiological and onsite and offsite toxicological exposures are assigned to Risk Bin III.

Effect of Transfer Pump Operation in Recirculation Mode

One of the associated hazardous conditions (AN102-CM-11) is that the additional heat generated by operation of a transfer pump in recirculation mode causes a tank bump. The 100-hp (75 kW) new generation transfer pump bounds the 30-hp pumps currently in use. Operation of this pump in DST 241-AZ-101 will be a total heat load of 61 + 75 = 136 kW. Using the heatup rate equations in RPP-6213, this heat load results in a heatup rate of 1.30 °F/day. Using the methodology described in Section 2.1.1, this heatup rate is sufficient to cause a tank bump in 11.5 days([210 °F – 195 °F]/1.30 °F/day = 11.5 days). The use of a transfer pump in an AWF tank for this period of time – without making a transfer – is considered to be "unlikely." This is the same frequency as the representative accident; therefore, no changes are made to the risk bin assignments when the pump is installed in any tank in the AWF.

In non-AWF DSTs, operation of a transfer pump in recirculation mode will not result in a tank bump. If the pump is installed in the normal location in the supernatant, the additional heat may eventually cause localized boiling of the supernatant, but will not heat the non-convective layer and a bump cannot occur. If the pump is inadvertently installed in the non-convective layer of a non-AWF DST, the additional heat may eventually cause localized steam bubble generation. However, the supernatant will be well below saturation temperature (non-AWF DSTs typically operate below 110 °F [RPP-5926]) and will quench the bubbles, thus preventing a tank bump. Additionally, the pump will tend to mix the sludge and supernatant if operated under these conditions, removing the conditions necessary for a tank bump to occur. Since the worst-case outcome is tank waste boiling, this initiator is assigned to Risk Bin III when the pump is installed in non-AWF DSTs.

Table 6. Qualitative Evaluation of Key Assumptions for Represented Hazardous Conditions. (2 sheets)

Key assumptions (KA) with references/basis	Assumption type	Potential effect on risk bin	Need to protect KA	Protection mechanism basis
High heat could cause waste boiling and release of radioactive aerosols to air.	Reasonably conservative.	Because the initiating event (long-term loss of cooling) is the same as for tank bump, the accident frequency of "unlikely" isassigned based on operating experience and engineering judgment.	No	N/A
A sudden addition of cooling water to SST 241-SX-114 could result in flashing to steam and releases of aerosols from tank headspace through the open riser. However, no SST has sufficiently high waste temperature to initiate boiling or flashing (RPP-5926).	Bounding (physically limiting).	These measured values were the basis for assigning the accident frequency "beyond extremely unlikely" to the hazardous condition associated with SST 241-SX-114.	No	N/A
Operation of transfer pump recirculation and addition of caustic causes waste temperature increase. Operation of the 75-kW (100-hp) new generation transfer pump for 11.5 days is assumed.	Bounds current operations.	Operation of a transfer pump in an AWF tank for over a week, without making a transfer, is so far beyond normal operations as to be considered "unlikely," based on operating experience and engineering judgment. Operation of a transfer pump in a non-AWF DST will not result in a tank bump.	No	N/A
A tank bump that results in a dome collapse could result in greater consequences than a tank bump alone. The maximum pressure generated by a tank bump with all vent paths sealed is 4 psig (RPP-6213). By comparison, the necessary pressure for tank damage is 60 psig (WHC-EP-0578).	Reasonably conservative.	These calculated values were the basis for assigning the accident frequency "beyond extremely unlikely" to a dome collapse caused by a tank bump.	No	N/A
In addition to a loss of electrical power, tank cooling could be lost if the prefilter becomes plugged with waste. Failure to pass air causes excess negative pressure resulting in tank bump. The ventilation system is capable of producing a maximum vacuum of only a few inches of water. This is insufficient to cause a tank bump (RPP-6213).	Reasonably conservative.	These calculated values were the basis for assigning the accident frequency "extremely unlikely" to a tank bump caused by excess negative pressure.	No	N/A
In addition to a loss of electrical power, tank cooling could be lost if the HEME, HEGA, or HEPA filters becomes plugged with waste.	Reasonably conservative.	Long-term (e.g., >25 days) loss of airflow could cause a tank bump. This was considered to be "unlikely" based on operating experience and engineering judgment.	No	N/A

Table 6. Qualitative Evaluation of Key Assumptions for Represented Hazardous Conditions. (2 sheets)

Key assumptions (KA) with references/basis	Assumption type	Potential effect on risk bin	Need to protect KA	Protection mechanism basis

Notes:

RPP-5926, 2003, *Steady-State Flammable Gas Release Rate Calculation and Lower Flammability Level Evaluation for Hanford Tank Waste*, Rev. 2A, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-6213, 2003, *Hanford Waste Tank Bump Accident and Consequence Analysis*, Rev. 2, CH2M HILL Hanford Group, Inc., Richland, Washington

WHC-EP-0578, 1993, *Flammable Gas Safety Issue Review Tank 241-SY-101*, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

AWF = Aging Waste Facility.
DST = double-shell tank.
HEGA = high-efficiency gas adsorber.
HEME = high-efficiency mist eliminator.
HEPA = high-efficiency particulate air (filter).
KA = key assumption.
N/A = not applicable.
SST = single-shell tank.

3.0 CONTROL SELECTION

The onsite toxicological consequences of the representative accident and associated hazardous conditions were assigned to Risk Bin II. All other consequences were assigned to Risk Bin III. A control decision meeting on October 8, 2002, indicated the need for one safety-significant SSC: the DST Primary Ventilation System. A supplemental control decision meeting on December 19, 2002, indicated that the applicability of this control was limited to the 241-AY and 241-AZ tank farms. The safety function of this SSC is to maintain the waste supernatant subcooled, thus reducing the frequency of a tank bump accident. If the supernatant is subcooled by 10 °F, significant tank bumps are prevented (RPP-6213). A flow rate of 64 ft^3/min is necessary to maintain the waste supernatant in DST 241-AZ-101 (the bounding case) at 210 °F, i.e., 10 °F subcooled.

If additional heat loads, such as transfer or mixer pumps, are installed in 241-AY or 241-AZ tank farms, higher air flows will be required. The required flows are as follows (RPP-6213):

Total tank heat load (kW)	Required air flow (ft^3/min)
100	112
175	217
250	337

A TSR limiting conditions for operation (LCO) ensures the operability of the DST Primary Ventilation System for the 241-AY and 241-AZ tank farms (see Table 3.3.2.4.7-4) and specifies a flow rate of 65 ft^3/min. The LCO also specifies an average waste supernatant temperature limit of 195 °F to allow adequate time to restore ventilation cooling following a loss of power, while remaining 10 °F below saturation temperature to prevent a tank bump accident. The emergency preparedness program was selected to verify that the DST Primary Ventilation System can perform its safety function following significant, relevant natural events (e.g., seismic events, high winds), thus decreasing the frequency of a tank bump accident.

The tank bump accident is not credible for DSTs outside the 241-AY and 241-AZ tank farms, based on the heat load of the waste currently present in the tanks. To prevent a future waste transfer from creating a tank capable of a tank bump, an administrative control for waste transfers has been selected that requires the receiving tank of any waste transfer to be evaluated against the three criteria described in Section 1.2.1 (heat load $\leq$ 11.3 kW, sludge depth $\leq$ 0.3 m [1 ft], or supernatant depth $\leq$ 1 m). If the receiving tank for the proposed transfer would fail all three criteria, thus creating the potential for a bump, the transfer is prohibited.

Defense-in-depth features were identified for the tank bump accident and associated represented hazardous conditions as described in RPP-14821, *Technical Basis Document for Defense-In-Depth Features*. No additional safety SSCs or TSR-level controls were selected within the defense-in-depth features identified for the tank bump accident and associated represented hazardous conditions.

4.0 REFERENCES

DOE-HDBK-3010-94, 2000, *Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities*, Change Notice No. 1, U.S. Department of Energy, Washington, D. C.

DOE-STD-3009-94, 2002, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports*, Change Notice No. 2, U.S. Department of Energy, Washington, D.C.

Klien, K.A., and R. J. Schepens, 2003, "Replacement of Previous Guidance Provided by RL and ORP," (letter 03ABD-0047/0300642 to E. K. Thomson, Fluor Hanford, Inc., and E. S. Aromi, CH2M HILL Hanford Group, Inc., February 4), U.S. Department of Energy, Richland, Operations Office, and Office of River Protection, Richland, Washington.

RPP-5924, 2003, *Radiological Source Terms for Tank Farms Safety Analysis*, Rev. 1, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-5926, 2003, *Steady-State Flammable Gas Release Rate Calculation and Lower Flammability Level Evaluation for Hanford Tank Waste,* Rev. 2A, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-6213, 2003, *Hanford Waste Tank Bump Accident Analysis*, Rev. 2, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-8218, 2001, *Generalized Feed Delivery Descriptions and Tank Specific Flowsheets*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-8369, 2003, *Chemical Source Terms for Tank Farms Safety Analyses*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-12395, 2003, *Offsite Consequences of Waste Tank Dome Failure,* CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-12444, 2003, *Technical Basis for the Tank Failure Due to Excessive Loads Representative Accident and Associated Represented Hazardous Conditions*, Rev. 0, CH2M HILL Hanford Group Inc., Richland, Washington.

RPP-13354, 2003, *Technical Basis for the Release from Contaminated Facility Representative Accident and Associated Represented Hazardous Conditions*, CH2M HILL Hanford Company, Inc., Richland, Washington.

RPP-13437, 2003, *Technical Basis Document for Ventilation System Filtration Failure Leading To An Unfiltered Release*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-13482, 2003, *Atmospheric Dispersion Coefficients and Radiological/Toxicological Exposure Methodology for Use in Tank Farms*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-13510, 2003, *Flammable Gas Technical Basis Document*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-13978, 2003, *Technical Basis for the Transportation Related Handling Representative Accidents and Associated Hazardous Conditions*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-14286, 2003, *Facility Worker Technical Basis Document*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-14821, 2003, *Technical Basis Document for Defense-In-Depth Features*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-14892, 2003, *Boiling Point Calculations for Selected Double-Shell Tanks*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-15088, 2003, *Consequences of Select Boiling Waste Scenarios For Waste Feed Delivery,* Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-15116, 2003, *Proceedings of the Nuclear Working Group and the Technical Working Group,* CH2M HILL Hanford Group, Inc., Richland, Washington.

WHC-EP-0578, 1993, *Flammable Gas Safety Issue Review Tank 241-SY-101,* Rev. 0, Westinghouse Hanford Company, Richland, Washington.

APPENDIX A

RISK BINNING MEETING ATTENDEES

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APPENDIX A

RISK BINNING MEETING ATTENDEES

SEPTEMBER 26, 2002

Joe Bevelacqua, ORP

Craig Carro, CHG2M HILL

Geoffrey Gelhaus, ORP

Jon Geisbush, CHG2M HILL

Tom Goetz, CHG2M HILL

Yusuf Noorani, ORP

Cliff Hampton, CHG2M HILL

Mark Hasty, CHG2M HILL

Steve Sanders, CHG2M HILL

Brad Smith, CHG2M HILL

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APPENDIX B

PEER REVIEW CHECKLIST

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APPENDIX B

PEER REVIEW CHECKLIST

Preparation and Review of Calculation Notes and Technical Basis Documents	**Manual**	**HNF-2353**
	Desk Instruction	**4.3, Rev. 4**
	Page	**11 of 12**
	Effective Date	**12/17/02**

ATTACHMENT C

CHECKLIST FOR TECHNICAL PEER REVIEW

Document Reviewed: RPP-13438 TANK BOUNP TECHNICAL BASIS Rev 0 3/6/03.

Scope of Review (e.g., document section or portion of calculation): RPP-13438 Rev 0 MARCH 6, 2003. & EXCEL SPREADSHEET.

Yes	No	NA*	
[X]	[ ]	[ ]	1. Previous reviews are complete and cover the analysis, up to the scope of this review, with no gaps.
[X]	[ ]	[ ]	2. Problem is completely defined.
[X]	[ ]	[ ]	3. Accident scenarios are developed in a clear and logical manner.
[X]	[ ]	[ ]	4. Analytical and technical approaches and results are reasonable and appropriate. *(ORP QAPP criterion 2.8)*
[X]	[ ]	[ ]	5. Necessary assumptions are reasonable, explicitly stated, and supported. *(ORP QAPP criterion 2.2)*
[X]	[ ]	[ ]	6. Computer codes and data files are documented. HAND CALCS VERIFIED. TV (EXCEL)
[X]	[ ]	[ ]	7. Data used in calculations are explicitly stated.
[X]	[ ]	[ ]	8. Bases for calculations, including assumptions and data, are consistent with the supported safety basis document (e.g., the Tank Farms Final Safety Analysis Report). FSA RPP-13033 SECTION 3.3.2.4.7
[X]	[ ]	[ ]	9. Data were checked for consistency with original source information as applicable. *(ORP QAPP criterion 2.9)*
[X]	[ ]	[ ]	10. For both qualitative and quantitative data, uncertainties are recognized and discussed, as appropriate. *(ORP QAPP criterion 2.17)*
[X]	[ ]	[ ]	11. Mathematical derivations were checked including dimensional consistency of results. *(ORP QAPP criterion 2.16)*
[X]	[ ]	[ ]	12. Models are appropriate and were used within their established range of validity or adequate justification was provided for use outside their established range of validity.
[X]	[ ]	[ ]	13. Spreadsheet results and all hand calculations were verified.
[X]	[ ]	[ ]	14. Calculations are sufficiently detailed such that a technically qualified person can understand the analysis without requiring outside information. *(ORP QAPP criterion 2.5)*
[X]	[ ]	[ ]	15. Software input is correct and consistent with the document reviewed. EXCEL
[X]	[ ]	[ ]	16. Software output is consistent with the input and with the results reported in the document reviewed. EXCEL
[X]	[ ]	[ ]	17. Software verification and validation are addressed adequately. *(ORP QAPP criterion 2.6)* (EXCEL) HAND CALCS TV
[X]	[ ]	[ ]	18. Limits/criteria/guidelines applied to the analysis results are appropriate and referenced. Limits/criteria/guidelines were checked against references. *(ORP QAPP criterion 2.9)*
[X]	[ ]	[ ]	19. Safety margins are consistent with good engineering practices.
[X]	[ ]	[ ]	20. Conclusions are consistent with analytical results and applicable limits.

[X]	[ ]	[ ]	21. Results and conclusions address all points in the purpose. *(ORP QAPP criterion 2.3)*
[X]	[ ]	[ ]	22. All references cited in the text, figures, and tables are contained in the reference list.
[X]	[ ]	[ ]	23. Reference citations (e.g., title and number) are consistent between the text callout and the reference list.
[X]	[ ]	[ ]	24. Only released (i.e., not draft) references are cited. *(ORP QAPP criterion 2.1)*
[X]	[ ]	[ ]	25. Referenced documents are retrievable or otherwise available.
[X]	[ ]	[ ]	26. The most recent version of each reference is cited, as appropriate. *(ORP QAPP criterion 2.1)*
[ ]	[ ]	[X]	27. There are no duplicate citations in the reference list.
[ ]	[ ]	[X]	28. Referenced documents are spelled out (title and number) the first time they are cited.
[ ]	[ ]	[X]	29. All acronyms are spelled out the first time they are used.
[ ]	[ ]	[X]	30. The Table of Contents is correct.
[X]	[ ]	[ ]	31. All figure, table, and section callouts are correct.
[X]	[ ]	[ ]	32. Unit conversions are correct and consistent.
[X]	[ ]	[ ]	33. The number of significant digits is appropriate and consistent.
[ ]	[ ]	[X]	34. Chemical reactions are correct and balanced.
[X]	[ ]	[ ]	35. All tables are formatted consistently and are free of blank cells.
[X]	[ ]	[ ]	36. The document is complete (pages, attachments, and appendices) and in the proper order.
[X]	[ ]	[ ]	37. The document is free of typographical errors.
[X]	[ ]	[ ]	38. The tables are internally consistent.
[X]	[ ]	[ ]	39. The document was prepared in accordance with HNF-2353, Section 4.3, Attachment B, "Calculation Note Format and Preparation Instructions".
[X]	[ ]	[ ]	**Concurrence**

Tom Tomaszewsky (Weirich & Associates)

Tom Tomaszewsky 3-11-03

Reviewer (Printed Name and Signature) Date

- If No or NA is chosen, provide an explanation on this form.

#27-30 performed by Tech-editing personnel.

#34 No chemical reactions cited.

CHECKLIST FOR TECHNICAL PEER REVIEW

Document Reviewed:

Scope of Review (e.g., document section or portion of calculation):

Yes	No	NA*	
[ ]	[ ]	[X]	1. Previous reviews are complete and cover the analysis, up to the scope of this review, with no gaps.
[ ]	[ ]	[X]	2. Problem is completely defined.
[ ]	[ ]	[X]	3. Accident scenarios are developed in a clear and logical manner.
[ ]	[ ]	[X]	4. Analytical and technical approaches and results are reasonable and appropriate. *(ORP QAPP criterion 2.8)*
[ ]	[ ]	[X]	5. Necessary assumptions are reasonable, explicitly stated, and supported. *(ORP QAPP criterion 2.2)*
[ ]	[ ]	[X]	6. Computer codes and data files are documented.
[ ]	[ ]	[X]	7. Data used in calculations are explicitly stated.
[ ]	[ ]	[X]	8. Bases for calculations, including assumptions and data, are consistent with the supported safety basis document (e.g., the Tank Farms Final Safety Analysis Report).
[ ]	[ ]	[X]	9. Data were checked for consistency with original source information as applicable. *(ORP QAPP criterion 2.9)*
[ ]	[ ]	[X]	10. For both qualitative and quantitative data, uncertainties are recognized and discussed, as appropriate. *(ORP QAPP criterion 2.17)*
[ ]	[ ]	[X]	11. Mathematical derivations were checked including dimensional consistency of results. *(ORP QAPP criterion 2.16)*
[ ]	[ ]	[X]	12. Models are appropriate and were used within their established range of validity or adequate justification was provided for use outside their established range of validity.
[ ]	[ ]	[X]	13. Spreadsheet results and all hand calculations were verified.
[ ]	[ ]	[X]	14. Calculations are sufficiently detailed such that a technically qualified person can understand the analysis without requiring outside information. *(ORP QAPP criterion 2.5)*
[ ]	[ ]	[X]	15. Software input is correct and consistent with the document reviewed.
[ ]	[ ]	[X]	16. Software output is consistent with the input and with the results reported in the document reviewed.
[ ]	[ ]	[X]	17. Software verification and validation are addressed adequately. *(ORP QAPP criterion 2.6)*
[ ]	[ ]	[X]	18. Limits/criteria/guidelines applied to the analysis results are appropriate and referenced. Limits/criteria/guidelines were checked against references. *(ORP QAPP criterion 2.9)*
[ ]	[ ]	[X]	19. Safety margins are consistent with good engineering practices.
[ ]	[ ]	[X]	20. Conclusions are consistent with analytical results and applicable limits.

Preparation and Review of Calculation Notes	**Manual**	**HNF-2353**
	Desk Instruction	**4.3, Rev. 4**
	Page	**12 of 12**
	Effective Date	**12/17/02**

[ ] [ ] [X] 21. Results and conclusions address all points in the purpose. *(ORP QAPP criterion 2.3)*

[X] [ ] [ ] 22. All references cited in the text, figures, and tables are contained in the reference list.

[X] [ ] [ ] 23. Reference citations (e.g., title and number) are consistent between the text callout and the reference list.

[X] [ ] [ ] 24. Only released (i.e., not draft) references are cited. *(ORP QAPP criterion 2.1)*

[X] [ ] [ ] 25. Referenced documents are retrievable or otherwise available.

[X] [ ] [ ] 26. The most recent version of each reference is cited, as appropriate. *(ORP QAPP criterion 2.1)*

[X] [ ] [ ] 27. There are no duplicate citations in the reference list.

[X] [ ] [ ] 28. Referenced documents are spelled out (title and number) the first time they are cited.

[X] [ ] [ ] 29. All acronyms are spelled out the first time they are used.

[X] [ ] [ ] 30. The Table of Contents is correct.

[X] [ ] [ ] 31. All figure, table, and section callouts are correct.

[ ] [ ] [X] 32. Unit conversions are correct and consistent.

[ ] [ ] [X] 33. The number of significant digits is appropriate and consistent.

[ ] [ ] [X] 34. Chemical reactions are correct and balanced.

[X] [ ] [ ] 35. All tables are formatted consistently and are free of blank cells.

[X] [ ] [ ] 36. The document is complete (pages, attachments, and appendices) and in the proper order.

[X] [ ] [ ] 37. The document is free of typographical errors.

[X] [ ] [ ] 38. The tables are internally consistent.

[ ] [ ] [X] 39. The document was prepared in accordance with HNF-2353, Section 4.3, Attachment B, "Calculation Note Format and Preparation Instructions".

[ ] [ ] [ ] **Concurrence**

NA check for those items not responsibility of tech editor.

CAROL J. LYNCH Carol J. Lynch 3-20-03

Reviewer (Printed Name and Signature) Date

RPP-14177

* If No or NA is chosen, provide an explanation on this form.

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